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Monthly Bulletin of the International Railway Congress Association

(English Edition)

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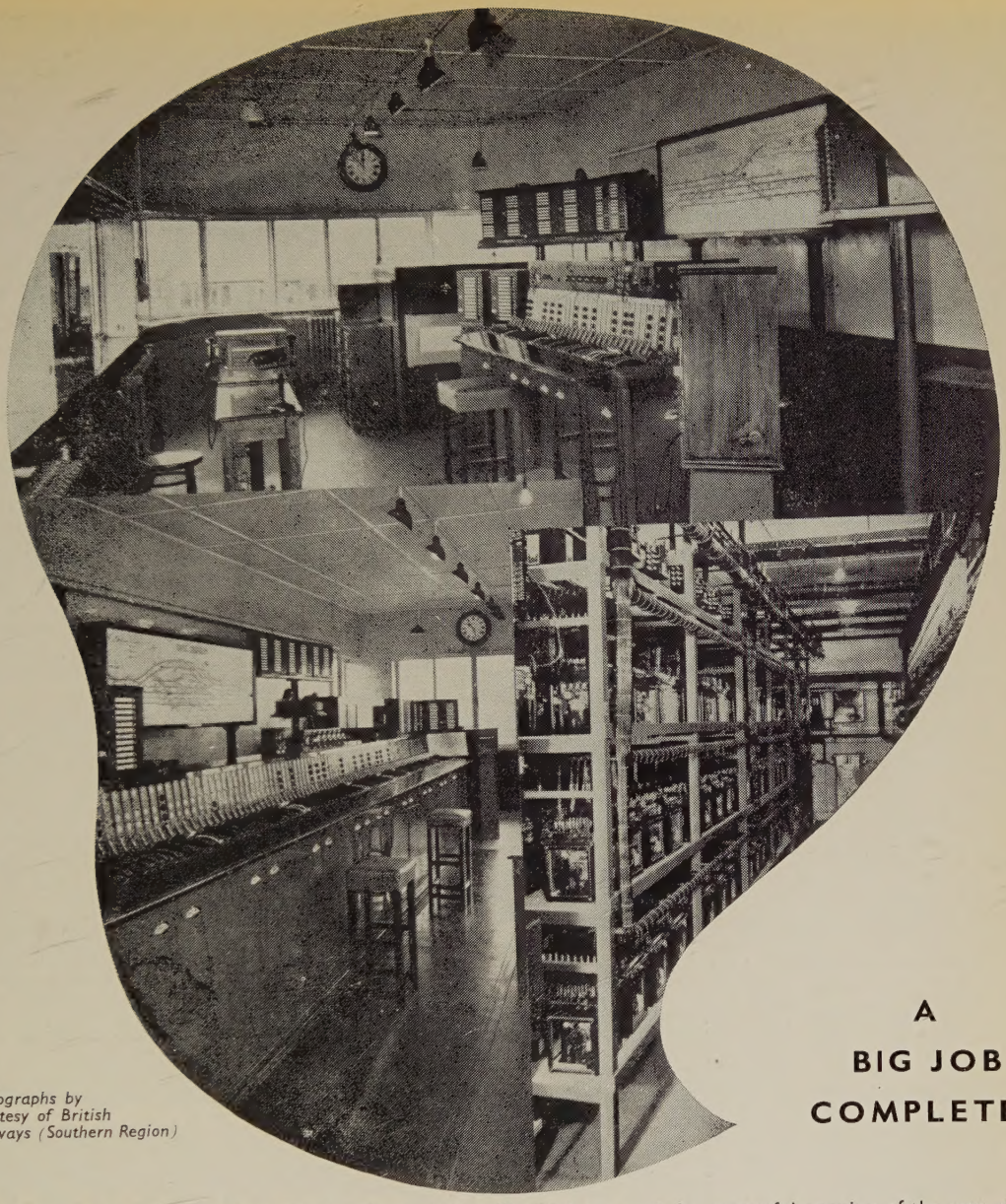

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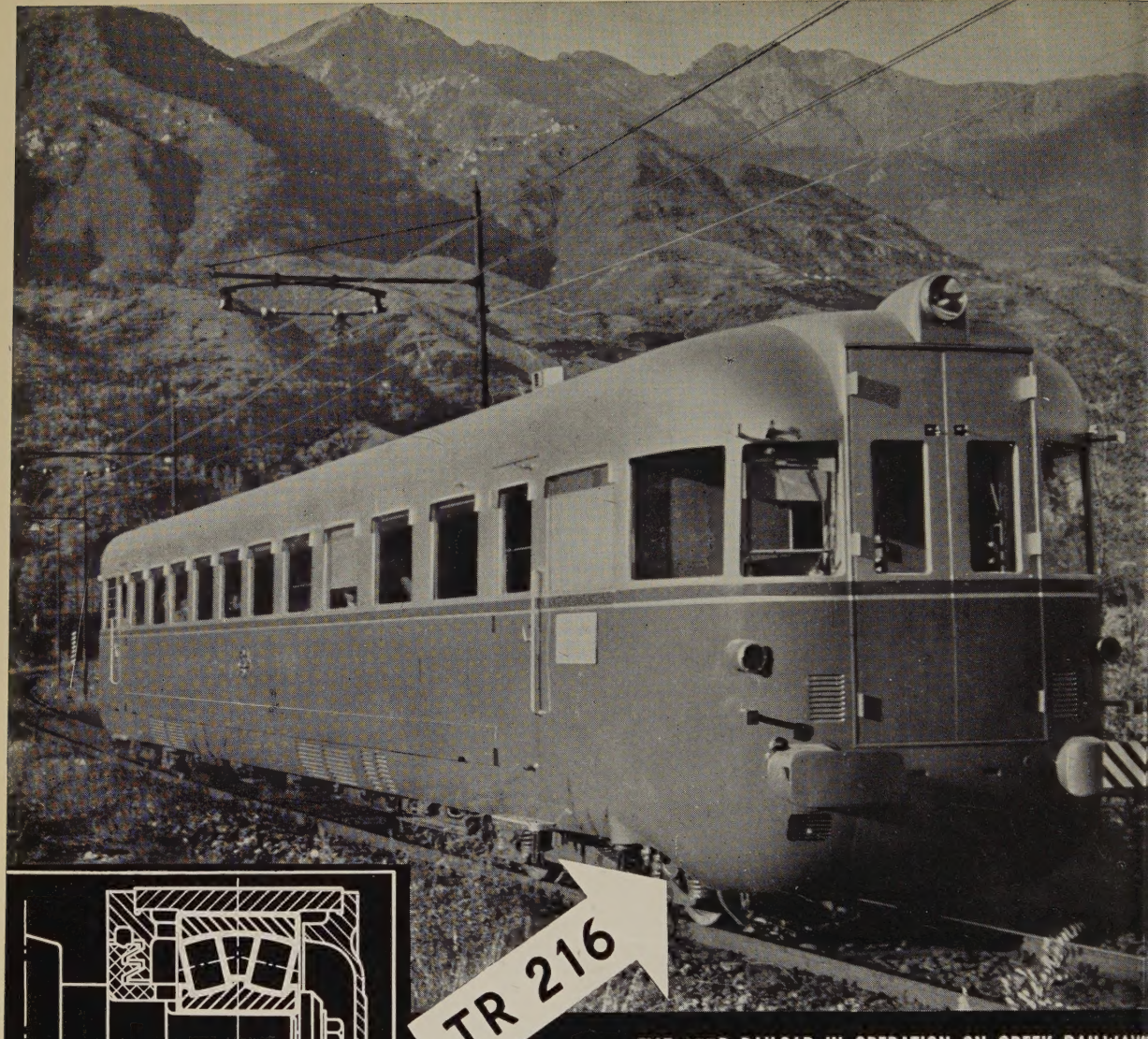

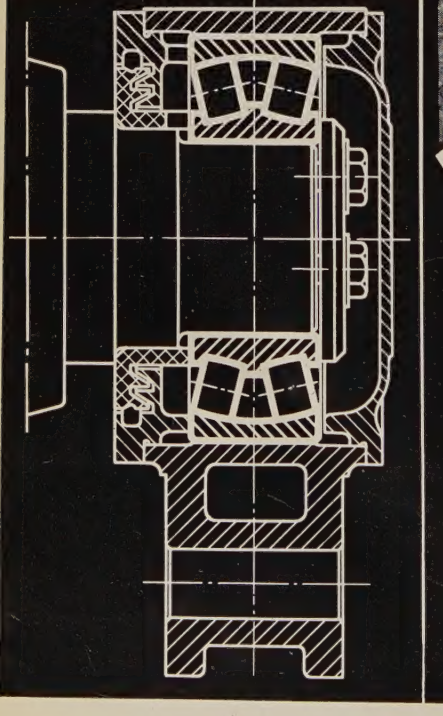

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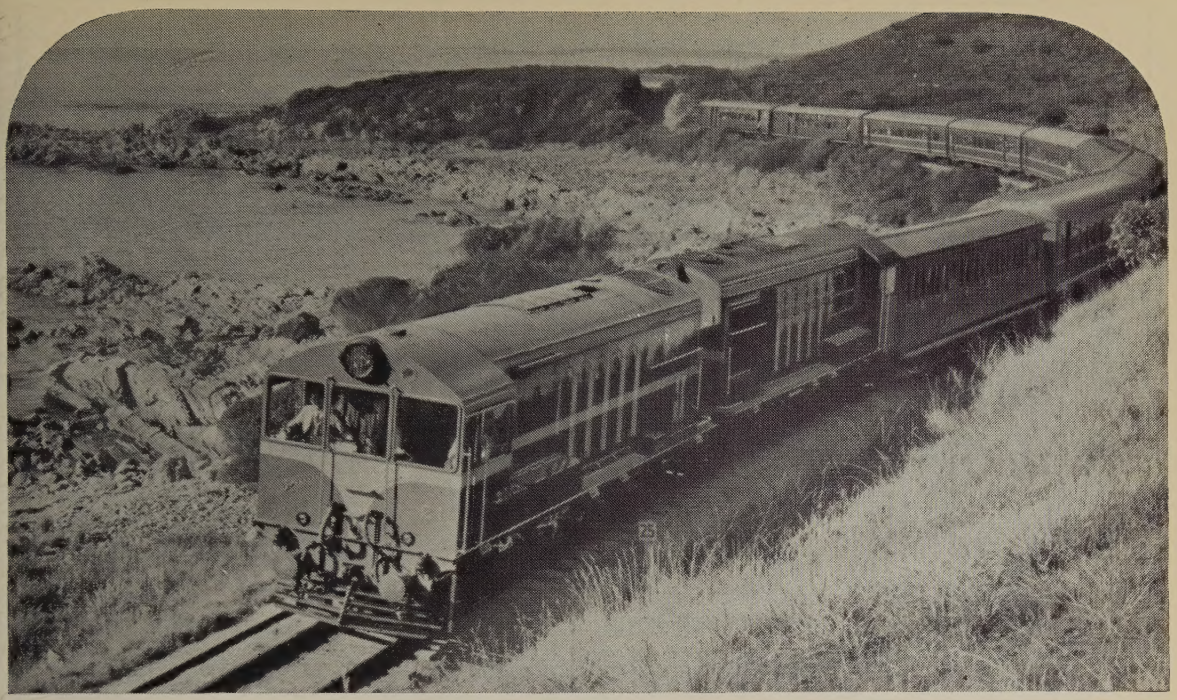

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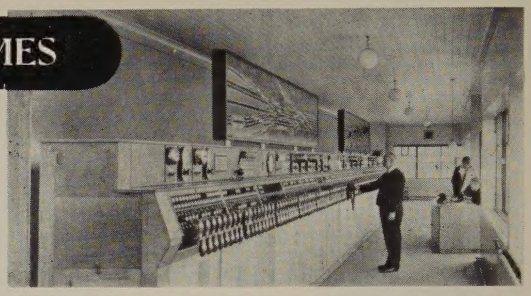

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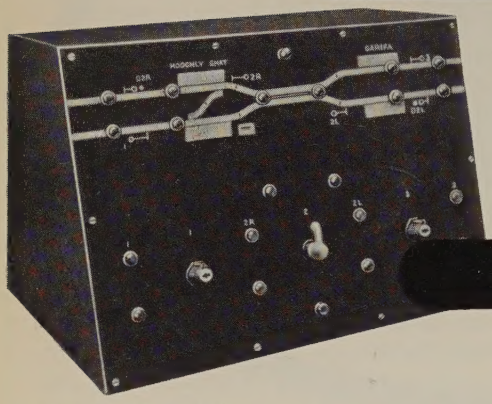

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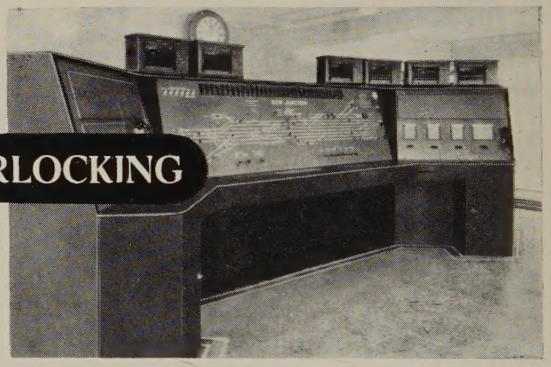

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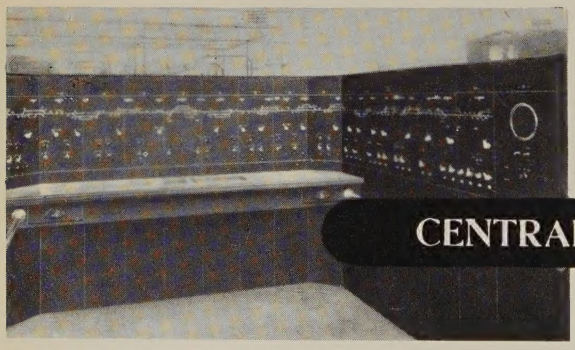

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MONTHLY BULLETIN

OF THE

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Vol. XXXIII. — No. 6. June 1956.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

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Lateral strength of permanent way when free from load,

by Roger SONNEVILLE,
Ingénieur des Arts et Manufactures, Chef de la Section des Recherches de la Direction des Installations fixes de la S.N.C.F.,
and André BENTOT,
Ingénieur des Travaux Publics, Inspecteur Divisionnaire de la Section des Recherches de la Direction des Installations fixes de la S.N.C.F.

This article is a continuation of one by the same authors which appeared in the International Railway Congress Bulletin in March, 1955.

With the intention of proceeding as far as possible with the extension of continuous welding of rails on lines with sharp curves, the Fixed Installations Research Section undertook the investigation and measurement of the comparative lateral strengths of different types of track.

This investigation, which has just been completed, includes two distinct series of measurements :

— Measurement of the lateral elasticity and strength of the track under rolling load, to show its capability for resisting, under the effect of lateral dynamic action, distortions of the alignment which would be liable to cause jumping from the track, the rails being under compression, during warm weather;

— Measurement of the resistance offered by the ballast to transverse displacement of a part of the track not under load; this is an investigation of the static resistance to the radial components of expansion on a curve.

The first series of measurements, carried out with the help of a « derailment wagon », was the subject of an article published in the *International Railway Congress Bulletin*, in March, 1955.

We will recall only that these measurements showed that an axle was capable of causing a permanent distortion of the alignment when the ratio of the transverse stress to vertical load exceeded a value of about 0.70 in the standard 50 kg (110 lbs.) track on firmly bedded wooden sleepers.

This ratio, corresponding to the threshold of permanent distortion is about 1, for the strongest superstructures, i.e. those equipped with metal or mixed sleepers or with heavy rail (62 kg (136 lbs.) P.L.M.). On the other hand, it falls to a value of little more than 0.40 (track on wooden sleepers with 46 kg (101 lbs.) rail, undermined by reballasting and corresponding cleansing and weeding or by recent renewal).

Whilst the first series of measurements

gave interesting results for comparing lateral resistance of the track to the transverse dynamic action, it also allowed comparison and classification of the various types of track from the point of view of their capabilities for supporting the lateral stresses peculiar to long welded rails and at the same time illustrating the choice to be made and the precautions to be taken, particularly during maintenance work.

The second series of measurements has, however, been found necessary to complete this investigation of the possibilities of extending the welding of rails by providing information on the strength of track when free from load.

On sharp curves it cannot be doubted that radial forces, due to temperature, cause distortion of the alignment, even though no trains pass over the track.

In practice, moreover, it is difficult to separate clearly the lateral movement of the track into two distinct actions, because the process of distortion produced on sharply-curved track, in front of and behind vehicles exercising heavy guiding forces involves both factors concurrently without any interval between them. Consequently, it would not seem to be easy to calculate the limits of equilibrium for welded track, with rails under compression, on a curved track during the passage of vehicles whose guiding forces are added to considerable static radial stresses.

On the other hand, it has seemed worth while to take static measurements of the strength of track when free from load and compare the different types of track. The sum of these measurements, dynamic and static, allows the calculation of a co-efficient of safety for a given track of given radius in certain specified conditions. Track equipped with 50 kg U 36 welded rail on wooden sleepers spaced at 60 cm (23.62 in.) between centres with double flexible rail spikes can be taken for reference. For this track, laid in a curve, a radius of 800 m (40 chains) has so far been considered to be the lower limit the safety of which has been confirmed by wide experience, even at very high speeds with a temperature rise of $+40^{\circ}$ C over the temperature when laid, provided that suitable precautions are taken as regards maintenance operations. The radial stress developed by this track, in these extreme conditions, is about 82 kg (180 lbs.) per sleeper.

Method of measuring the lateral strength of the track when free from load.

In taking these measurements, the influence of the inherent rigidity of the track framework was deliberately eliminated by working on short lengths subjected to a uniform stress in a transverse direction. Thus, only the influence of the ballast and the friction of the sleepers on it was retained, the weight of the rail, in particular, acting only to increase the friction and doing nothing to affect the rigidity.

This method may appear surprising and we consider it worth while to give some reasons :

Firstly, consideration of the rigidity of the track frame would be a duplication of the measurements taken with the aid of the derailment wagon, which took this rigidity into account, with its stabilising influence on the alignment but also with its disturbance value, since the continuity of the « beam » formed by the track extends both in advance and

in the rear of the maximum stress located in the line of the axle and affects non-loaded and even slightly counter-loaded zones. This continuity is favourable in one sense and unfavourable in another.

Moreover, experience has shown that movement of the track towards the outside of sharp curves generally extends

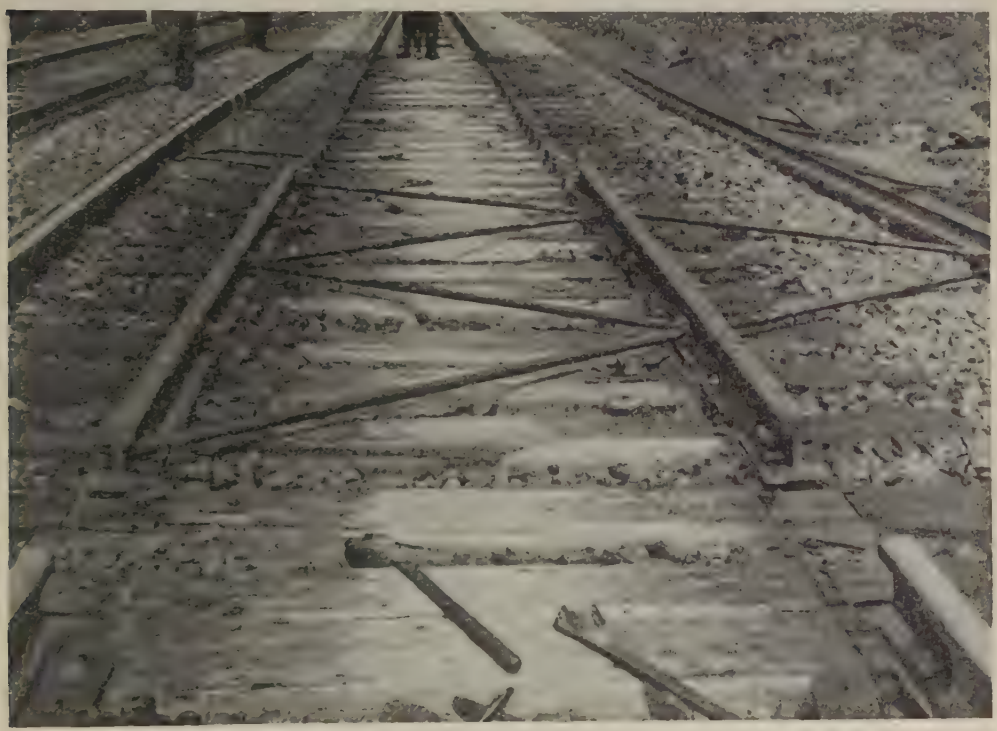


Fig. 1. — General view of a section of track to be measured, showing the staying for lateral movement.

over a considerable length of the track and is restricted to a fairly moderate amplitude so that the variation in curvature when the alignment of the curve is disturbed remains negligible and only slightly affects the actual rigidity of the framework.

Finally, in the case with which we are concerned, of an investigation into the equilibrium of a section of curved track subject to a uniform centrifugal radial force, the basic stabilising factor is simply the ballast (resistance and friction). As is clearly demonstrated by the measurements taken, *the resistance of the ballast is at a maximum at the beginning of displacement* whilst the stabilising forces resulting from the rigidity of the track are nil at the beginning of the displacement and only come into play with a distortion of considerable magnitude with a large variation in the curvature.

Contrary to the opinions of certain Railway Administrations, which attach great importance to the rigidity of the frame, corresponding to the standard idea

of axial compression, we consider that it is the ballast alone which ensures the stability of the track, which corresponds to the idea of the track subjected to a uniformly distributed radial force, balanced by the thrust of the ballast, also considered as uniformly distributed.

incorrect alignment of the fastenings when tightened) which would have created internal stresses.

We have thus considered that measurement of the strength of the track when free from load in a transverse direction would be best adapted to an investigation

Fig. 2. — Dynamometer for measuring pull and « artillery » type fixed point.

Apart from what we know of the danger of a rigid track in relation to the dynamic forces of the vehicles, it may also be feared that this rigidity may give rise to dangerous forces which could be superimposed on the actions which tend to distort the track alignment; this would be the case, for example, with a track poorly laid (sleepers laid off square,

of the stability of welded track, as an adjunct to the measurements already made with the derailment wagon on loaded track.

Procedure for taking measurements.

The length of track selected for taking measurements was 5 m (16' 5''). This choice was a compromise between the

desire to cover sufficient sleepers to provide an average and the need for limiting the pull to a value compatible with the equipment — winch, fixed point and dynamometer.

For the recording to have a purpose, it was essential to work on an operated section of track and to take care that the bedding was unchanged at the time of taking the measurements. For this reason, therefore, only two rails, one in each line, were removed and replaced by two lengths of the same type of rail, carefully secured by coach screws and specially stayed to form a rigid beam (fig. 1). This stayed « beam » was connected by two symmetrical rods to a dynamometer which was itself connected to a winch supported by an artillery-type fixed point (fig. 2).

Recordings and measurements of the displacements of the track unit were carried out with the aid of « Bienfait ripamètres » (four per 5 m length), located between the sleepers, anchored in the ballast on the side opposite to the displacement and able to show clearly the displacement to about half a millimetre (fig. 3).

Fig. 3. — Arrangement of « ripameters » for measuring lateral displacement.

The transverse pull was applied progressively whilst the operato s noted the displacements recorded by the « ripa-

meters » located along the 5 m section. Each test was continued until there was appreciable movement of the section over some tens of centimeters.

To obtain information wide enough to be of practical value, the measurements were taken on lines varying in strength, amount of traffic, age and also in types of sleeper and ballast. Investigations were subsequently undertaken on a single line carrying a medium amount of traffic (Nantes-Bordeaux) into the influence of current maintenance operations on the strength of track when free from load, as was done with the derailment wagon.

Results of the measurements.

As the density of the sleepers varied slightly, according to the line, and so that the results will be comparable, the measurements are expressed in *kilos per sleeper*. For track laid on longitudinal sleepers, it was assumed that an 18 m (60 ft.) rail had an equivalent of 30 transverse sleepers (See table, fig. 4.)

These results corresponded in each case to numerous measurements and it is the average lateral strength which is quoted. The variations were remarkably small.

They give rise to several comments :

It may be recalled that no maintenance operations had been carried out for several months before the measurements were taken and they thus related to well-stabilised track, subject to normal traffic.

It appeared that :

— the type and shape of the sleepers played a very important part, much greater than the weight of the rail. Metal sleepers, despite the fact that their weight was about equal to that of wooden sleepers, are very well bedded into the ballast, thanks to the shape of their ends. The R.S. mixed sleepers with underside moulded by compression of the concrete during fabrication, are particularly stable, partly because of their weight (190 kg = 419 lbs.) and partly because of their wide double bearing surface against the ballast. The R.S. type, B., which is oval in shape, is not nearly so good and its use has been abandoned for this reason;

— the type of ballast and its age are of negligible importance. Slag ballast, with its high friction, seems to be the best, despite its low density. It appears that 10/30 gravel offers lower resistance which would explain the surprisingly mediocre results obtained with the Laval longitudinal sleepers. These would be improved by impressing during manufacture to avoid the underside being completely smooth. The same applies to prestressed concrete sleepers;

— contrary to what may be first thought to be probable, widening of the ballast bed above 1 m (3' 3 $^3/_8$") seems to be useless. On the other hand, a raised bed, to form a cushion whose weight is effective in the immediate vicinity of the sleeper ends, appears more efficient;

— the lowest result (340 kg = 750 lbs.) obtained with a standard 46 kg track is for recently laid track, whilst the same strength on old, consolidated ballast is much more resistant (460 kg = 1 014 lbs.);

Types of rail	Types of sleeper	Types of fittings	Nature of ballast — age	Lateral strength per sleeper
46 K U 33	Creosoted hardwood, without soleplate, new track, incompletely stabilised.	6 coach screws, 23 × 120	broken stone, 20/40 — 1952	340 K
46 K U 33	Creosoted hardwood, without soleplate, but with four sleepers in nine replaced one month before the measurements	— dº —	broken stone, 20/40 — 1928 stepped 1.20	410 K
46 K U 33	Same age of track as above, but without replacement of sleepers	— dº —	— dº —	460 K
50 K U 36	STUP prestressed concrete — smooth underside	elastic spikes	slag 30/50 — 1950	530 K
50 K U 36	V.W. prestressed concrete — smooth underside	— dº —	— dº —	540 K
62 K S 52	Creosoted hardwood, inclined soleplates, old stabilised track	coach screws 20	broken stone 30/50 — 1938	600 K
46 K U 33	Creosoted hardwood without soleplate	6 coach screws, 23 × 120	broken stone 30/50 — 1950 raised, reinforced step	650 K
50 K U 36	Creosoted hardwood with soleplates	6 coach screws, 23 × 140	slag, 30/50 — 1951	660 K
50 K U 36	« Laval » longitudinal sleepers	elastic spikes	gravel 10/30 — 1953	700 K
46 K U 33	Mixed concrete RS - B - smooth underside	— dº —	broken stone, 20/40 — 1952	710 K
45 K NORD	Standard metal	rigid clips	general — 1927	730 K
46 K U 33	Mixed concrete, RS-C moulded underside	elastic spikes	broken stone 20/40 — 1953	860 K

Figure 4. — **Strength per sleeper on various types of track.**

— finally, it is particularly significant that the replacement of four sleepers out of nine, one month before the measurements, may have reduced the lateral strength of the track by 11 % (410 in place of 460) even though this relates to a line with particularly heavy traffic (Houillères line, 45 000 tons per day). This shows the danger of replacing sleepers by « sampling » on welded track. The bedding of the track and the stability of the ballast are affected by it for a considerable period.

Reinforcement of the ballast.

Some investigations have been made into the effect of reinforcing the profile of the ballast, on the lateral strength of the track when not under load and for this purpose special cross-sections have been created, standard on some systems, to assess the value of the additional expenditure on the safety of the long rails.

The following table, figure 4, gives the results compared with an adjacent track of the same weight with a normal cross-section.

These figures show the preponderant role played by the ballast which comes into effect, as would be expected, by its mass. The lateral strength of the non-loaded track thus clearly results from the sum of two factors : the friction of the sleepers, particularly the underside, and also the internal friction of the mass of ballast affected by the thrust of the end faces of the sleepers and in the case of the « Italian » section by the thrust of the rail. The reinforcing of the profile of the ballast thus, leads to some very high lateral strengths, in the case of mixed sleepers which can support it so long as corrosion of the stays does not create a risk. On the other hand, the simple full profile does not provide any appreciable benefit with wooden sleepers; but it is exactly these for which any means must be sought to raise an apparently low figure and this simple and relatively cheap method provides a gain of about 20 %.

If the « Italian » type section seems

	Normal profile	Full profile to top of sleepers. Dressed centres	Full profile stepped to top of web. « Italian » type
46 kg wooden sleepers, standard layout, 1952	340 kg	410 kg	600 kg
46 kg RS. B. sleepers, smooth underside, 1952	710 kg	1 000 kg	1 100 kg
46 kg Rs. C. sleepers, moulded underside, 1953	860 kg	1 040 kg	1 250 kg

Figure 5. — **Influence of the cross section of the ballast.**

to be a luxury, and gives rise to considerable difficulties, particularly for inspection and maintenance of fittings, or for insulation, the use of a full profile appears to be capable of increasing, with a minimum of expense, the lateral strength of the track in special cases where the safety of the welded track may depend on it. This however assumes that to avoid complications in maintenance operations for levelling, that shovel packing — which demands stripping — must be abandoned. Mechanical tamping with vibrators is, on the other hand, facilitated by a greater depth of ballast.

Influence of maintenance operations.

Measurements made with the derailment wagon have shown the influence of any maintenance operations on the lateral strength of loaded track and the necessity for care in these operations, under strict rules, having regard to the unsettling effect on the track; it has seemed beneficial to take similar comparative figures for track not under load.

The results of these measurements taken on the Nantes-Bordeaux line, with medium traffic (10 000 tons per day) and with the same types of track as in figure 5, are given below :

Maintenance operations	46 kg rail with broken stone ballast	
	wooden sleepers standard layout	R.S. concrete, type B
Stable track, before work	340 kg	710 kg
Cleared for shovel packing	300 kg	610 kg
Immediately after shovel packing, before recovering	170 kg	490 kg
48 hours after shovel packing, recovered	250 kg	570 kg
Immediately after mechanical tamping	280 kg	650 kg
48 hours after mechanical tamping	290 kg	700 kg

The results engender a certain prudence in the method of shovel packing; they also provide an idea of the influence of friction between the underside of the sleepers and the ballast and the undesirable effect of the still loose gravel under them.

It was also noted during the measurements on loaded track that, starting with a stable track, its lateral strength fell as soon as the threshold of permanent deformation was reached. On the contrary, with a track already unsettled by a maintenance operation, the lateral strength remained constant, even with a displacement of more than 10 centimeters. This feature was also brought to light by supplementary measurements on non-loaded track; whilst the lateral strength reached its maximum with a displacement of 5 mm (3/16 in.) and then remained

Fig. 6. — Line from Carnoules to Gardanne — Mediterranean area. This was the first use of welded track (1954) on a sharp curve (R = 500 m (25 chains). 800 m rails on RS. sleepers) permitted as a result of these investigations.

constant if on a track immediately following mechanical tamping or packing; on wooden sleepers, on the contrary, the strength dropped sharply from 10 to 15 % on stable track as soon as the movement had reached several millimetres and then stabilised itself.

This peculiarity must be noted. It agrees with the same generally admitted idea that a track is more stable if it is less disturbed. It also shows that a simple lateral shift of the track to rectify the alignment, even of 3 to 4 mm (1/9" to 5/32") affects its stability and that

the effects of truing up may be purely ephemeral if it is intended to correct hammer blow of rough engines working over this track.

Conclusions.

The measurements of lateral strength of track when free from load have provided confirmation or have supplemented the observations made with the derailment wagon.

They show, first of all, that there is very great difference of lateral stability between certain types of track and that a comparison is not favourable to the standard type of track on wooden sleepers. Recent tests have confirmed this.

Moreover, whatever maintenance operations may be undertaken with welded track, truing up, re-levelling, replacing sleepers, re-ballasting, it upsets the stability to a greater or lesser degree and calls for precautions to be taken.

Abundance of ballast, deep rather than wide, increases the lateral stability of the track, but increases the cost of maintenance operations which call for removal of ballast.

All the observations made on the lateral instability factors of the track are applicable to longitudinal stability which results from the same factors. They thus make a contribution, certainly qualitative and possibly comparative, to the struggle between rail creep and longitudinal equilibrium of welded track.

Finally, these measurements provide a means of selecting the method of increasing transverse stability of welded track, where this is necessary, and especially on curves. If it is admitted that welded track on wooden sleepers gives no cause for anxiety in curves of radius greater that 800 m with temperature changes in the region of 40° C compared with the temperature when laid, it is nevertheless possible to extend the field of application of the technique of welded track to curves of much smaller radius, provided that weight and ballast are chosen which will increase the lateral strength proportionately to the increase in curvature (fig. 6).

[656 .212 .7 (44)]

Mechanised goods depot at Lyons-Guillotière,

by M. Delacarte,

Chef du Service de l'Exploitation de la Région Sud-Est de la Société Nationale des Chemins de fer français,

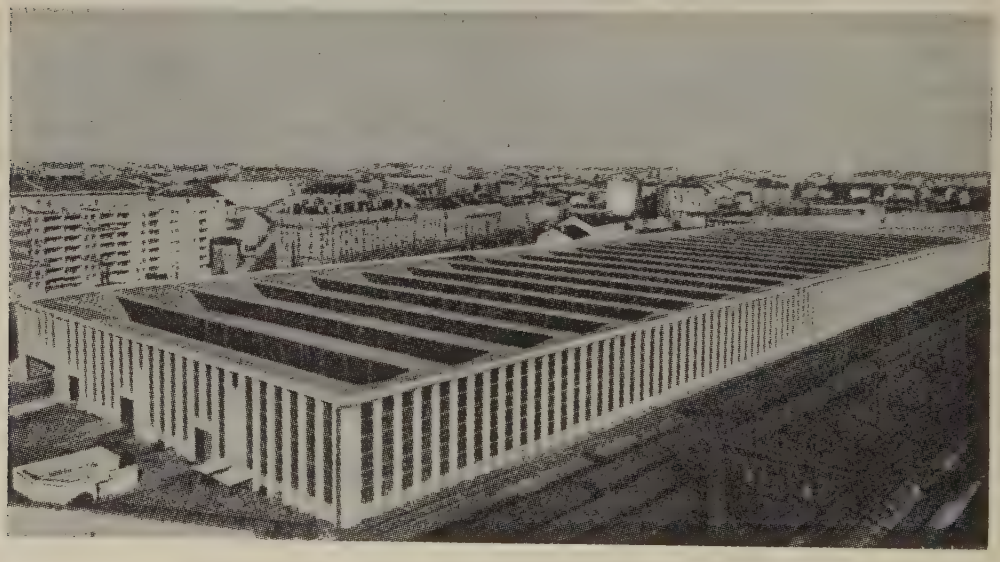
and M. Bonnot,

Chef de gare principal à Lyon-Guillotière.

Revue Générale des Chemins de fer, June 1955.)

Before the 1939 war, the sundries traffic (normal as well as accelerated) of the Lyons region was handled by five goods depots of conventional type, situated at Lyons-Vaise, Lyons-Brotteaux, Lyons-Perrache, Lyons-Guillotière and Badan. These five depots together had a covered deck area of 43 600 sq. m (52 200 sq. yds), not including the areas of tracks and forecourts.

This dispersion was onerous. The almost complete destruction of the depots in 1944 provided an opportunity to study the problem afresh. Moreover, the fusion of normal and accelerated traffic which had meanwhile taken place, called for a complete remodelling of the system formerly used.



(Cliché Borgé, Lyons.)

Fig. 1. — Perspective view of the shed for sundries forwarded.
In the background, on the right, is the shed for sundries received.

A scheme was therefore studied for the construction, in lieu of the reconstruction of the former installations, of a single modern goods depot, and as the French

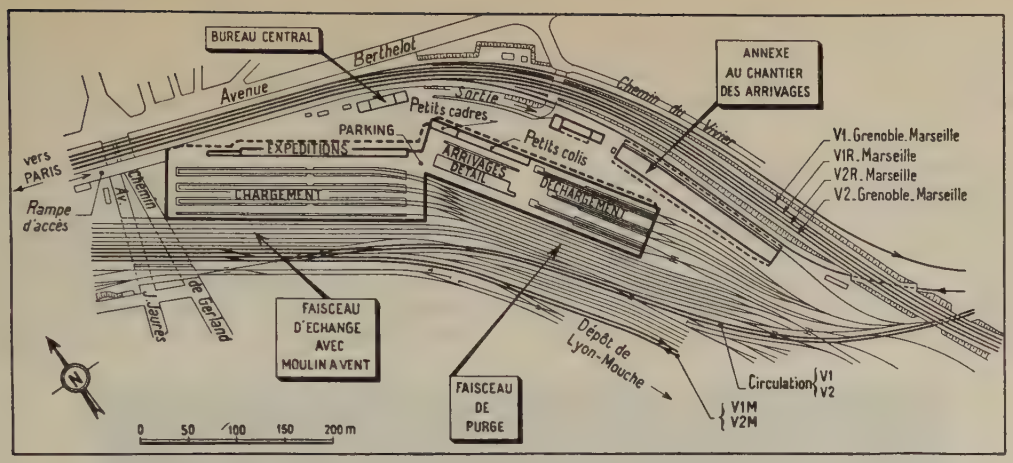


Fig. 2. — Plan of the mechanised depot.

Explanation of French terms:

Chargement = loading. — Expéditions = forwarded traffic. — Arrivages détail = sundries received. — Déchargement = unloading. — Petits cadres = stillages. — Petits colis = smalls. — Bureau central = central office. — Rampe d'accès = access ramp. — Sortie = exit. — Annexe du chantier des arrivages = annex for sundries received. — Faisceau de purge = group of « drain » sidings. — Faisceau d'échange avec Moulin à Vent = group of exchange sidings with Moulin à Vent marshalling yard.

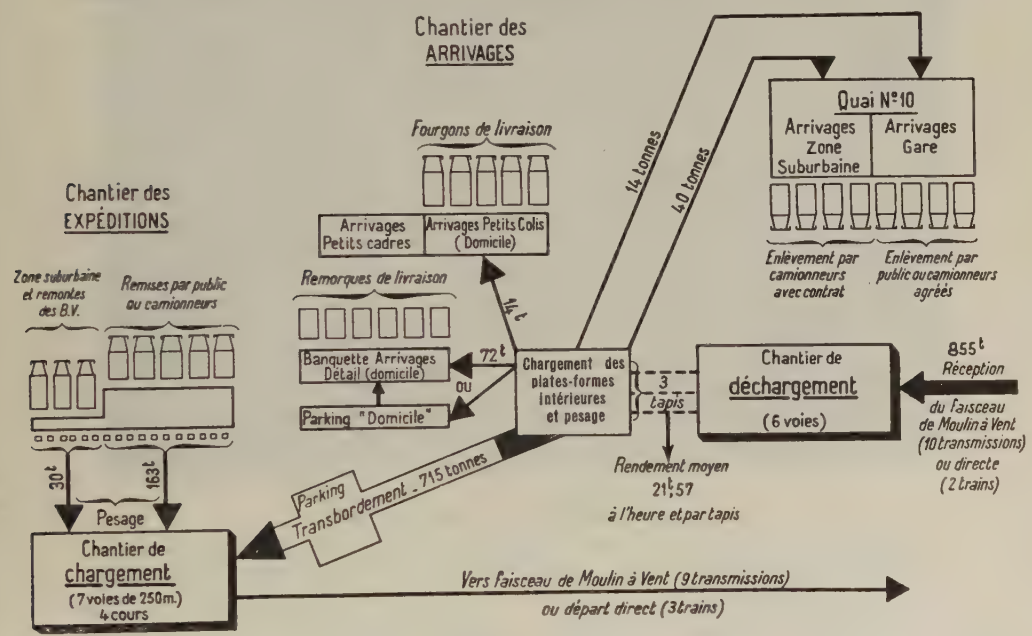


Fig. 3. — Working scheme of the depot.

Explanation of French terms:

Réception du faisceau de Moulin à Vent (10 transmissions) ou directe (2 trains) = traffic received from Moulin à Vent marshalling yard (10 transfers a day) or direct (2 trains a day). — Chantier de déchargement (6 voies) = unloading site (6 tracks). — Rendement moyen à l'heure et par tapis = average output per hour per conveyor. — Chargement des plates-formes intérieures et pesage = loading and weighing of internal movement vehicles. — Quai n° 10 = No. 10 platform. — Arrivages zone suburbaine = sundries received for the suburban zone. — Arrivages gare = sundries received for collection at the depot. — Enlèvement par camionneurs avec contrat = collection by contract carriers. — Enlèvement par public ou camionneurs agréés = collection by the public or approved carriers. — Chantier des arrivages = site for inwards traffic. — Arrivages petits colis (domicile) = smalls received for local delivery. — Arrivages petits cadres = stillages received. — Fourgons de livraison = delivery vans. — Parking domicile = parking area for local deliveries. — Banquette arrivages détail (domicile) = bench for sundries received for local delivery. — Remorques de livraison = road delivery trailers. — Parking transbordement = parking area for transhipments. — Chantier de chargement (7 voies de 250 m — 4 cours) = loading site (7 tracks of 250 m length; four loading yards). — Pesage = weighing. — Chantier des expéditions = forwarding site. — Zone suburbaine et remontes des B. V. = traffic forwarded from the suburban zone and from in-town parcels offices. — Remises par public = forwarded by clients or cartage agents. — Vers faisceau de Moulin à Vent (9 transmissions) ou départ direct (3 trains) = to the exchange sidings for Moulin à Vent marshalling yard (9 transfers a day) or direct departure (3 trains a day).

National Railways decided, at that time, to seek inspiration from the mechanised goods depots recently constructed in Great Britain, it is on that type that the new depot was modelled. The choice of site fell on Lyons-Guillotière station, by reason of the railway as well as town collection and delivery facilities available there (1).

That was the origin of Lyons-Guillotière mechanised goods depot which consists, essentially, of four main « working sites » :

— the « unloading » and « receiving » sites, accommodated in the « south shed », a building of 262 m (860 ft) length and 61.50 m (202 ft) width, constructed in reinforced concrete with steel framework; and

— the « forwarding » and « loading » sites, housed in the « north shed », a building of 267 m (876 ft) length and 83.30 m (273 ft) width, constructed entirely in reinforced concrete (figs. 1 and 7).

Together, these two buildings contain a covered area of 38 000 sq. m (46 000 sq.

Fig. 4. — Unloading site. No. 1 conveyor.
In the centre, the conveyor. On either side, the internal movement vehicles loaded with packages. In the background, wagons in the process of being unloaded. On the left, an electric tractor coupling up to a rulley.

(1) See « Revue Générale des Chemins de Fer » of August 1948, January 1949 and February 1952. The article in the January 1949 issue described the operation of the mechanised depot as it was envisaged at the time. In numerous respects, the final organisation differs greatly from the one then envisaged.

yds) which, owing to the small number of stanchions, is largely unrestricted.

This area cannot be readily compared with the total covered area of 43 600 sq. m (52 200 sq. yards) existing before the war, as a good deal of it is destined for the movement of road vehicles and the standage of railway wagons during unloading or loading. The total covered area now in use is therefore considerably smaller than that available in 1939.

Commenced in May, 1947, the construction work, slowed down by the steel shortage, extended over six years, and the sheds were taken into use in four stages :

— forwarding service, on 15th October, 1951;

— unloading service, with two conveyors and transhipment, on 25th August, 1952;

— inwards sundries and smalls, on 5th October, 1952;

— complete service, with three conveyors, on 17th May, 1953.

Fig. 5. — Inwards traffic site.
Enlarged bench destined for sundries.
Two tractors hauling rulleys distribute the packages along the bench.

I. — DESCRIPTION OF THE INSTALLATIONS.

The four sites (unloading, receiving, forwarding, loading) are arranged as follows (figs. 2 and 3) :

Unloading.

This site, nearest ot the southern end, is equipped with three conveyors of the type adopted for all the mechanised

depots of the French National Railways (Paris-Tolbiac, Noisy, Lyons, Avignon, Angers) : width 1 m (3′ 3″), rate of travel 15 m (49 ft) per minute, fixed benches of 0.80 m (2′ 7 1/2″) width on either side.

Each conveyor is flanked, over a length of 90 m (295 ft), by two tracks which receive, alternatively, in strings of eight, the sundries wagons (known as « wagons d'affectation » or « assignment wagons ») to be unloaded. At the delivery end of the conveyors are arranged, transversely, internal movement vehicles (rulleys), the purpose of which is explained later on (fig. 4).

Each of these three installations centred on a conveyor is known, at Guillotière Depot, as a « band » (a term derived from the « travelling band » of a production line).

Received sundries.

This site is adjacent to the one just described and comprises :

— firstly, a deck of 116 m (380 ft) length and 9 m (29 1/2 ft) width, destined for the arrival of smalls (up to 50 kg) and stillages for local delivery. This deck is served by the rulleys specially assigned to this type of received traffic;

— secondly, a deck known as « enlarged bench », 103 m (338 ft) long and 13 m (43 ft) wide, i.e. fairly narrow, where the rulleys carrying received sundries of over 50 kg weight, destined for local delivery, are lined up (figs. 5 and 6);

— finally, an annex (which has retained its old name of « No. 10 platform ») constructed at some distance

(Cliché Borgé, Lyons.)

Fig. 6. — Site for inwards traffic.

Another view of the enlarged bench. On the right, town delivery trailers. Note the mobile two-way loudspeaker telephone installation suspended from the ceiling.

from the shed, destined for packages to be collected at the depot, and particularly those collected by cartage agents under contract, who have received delivery orders from certain clients; this annex also serves for packages delivered by the S. N. C. F. road services serving the Lyons region.

Loading.

This site, likewise situated in the north shed and occupying the major part of it, comprises seven loading tracks of 250 m (820 ft) length, bordering on four concrete-paved cartways (one of 11.50 m [38 ft] width and three of 8 m [26 ft] width).

(Cliché Borgé, Lyons.)

Fig. 7. —Site for outwards traffic.
Deck of 170 m length for the reception of packages.

Forwarded sundries.

Situated in the north shed, this site comprises (fig. 7) :

— a deck of 170 m (558 ft) length and 9 m (29 1/2 ft) width, along which are permanently lined up the internal movement vehicles destined to handle all the forwarded sundries as soon as they have been checked and labelled;

— a bench of 45 m (148 ft) length and 2.50 m (8′ 2″) width, destined for direct transhipment to other internal movement vehicles, of sundries forwarded from the Lyons in-town parcels offices or the suburban railway stations served by S. N. C. F. road collection services.

These tracks are designed to accommodate all the sundries (« assignment ») wagons, departing from Lyons-Guillotière Depot.

Depot sidings.

All these sites are served jointly by sidings outside the depot, known as « drain » and « feed »-tracks, viz. :

— a group of eight sidings of 90 m (295 ft) length, directly connected with the unloading tracks (south shed);

— a group of seven sidings of 250 m (820 ft) length, directly connected with the loading tracks (north shed).

The depot disposes, in addition, over a

group of transfer sidings connected with Lyons-Guillotière marshalling yard, which is known as « Moulin à Vent ». This group comprises three sidings, two of which are electrified at their southern ends, whilst the third is electrified throughout. These sidings also permit the departure and arrival of trains of sundries wagons which by-pass the marshalling sidings and are formed or received directly at the depot.

Control office.

This complex and extensive organisation has its « brain » in the form of a Depot Control Office, known as « P. C. H. » (« Poste de commandement de la Halle »), and entrusted with the direction and control of the work of all the sites. This Control Office, housed in a glazed tower, is situated near the South Shed and affords excellent views over the unloading site (particularly the conveyors), the arrival site and the tracks. The office has telecommunication facilities (telephones, loudspeakers) with the sites under its control and with the shunting control office (« P. C. T. ») of the station.

The office is thus able to co-ordinate the work of all handling and shunting staff and to control the movements of the internal movement vehicles.

II. — HANDLING EQUIPMENT.

The equipment used for the transport of packages between the different sites consists, in the main, of :

a) 230 internal movement vehicles (figs. 4 and 5) of the type generally used in mechanised goods depots, with a loading platform of 3.76 m (12′ 4″) length and 2.70 m (8′ 10″) width, carrying a payload of 1.5 tons. These vehicles are fitted with four legs, each with a small wheel turning freely around a vertical axis, so that the vehicle can make small movements on the floor and can be placed accurately into position.

Six of these vehicles are equipped, on three sides, with latticed racks for the transport of small parcels in several layers.

The floor of twenty others has been reinforced with corrugated sheet iron so as to be able to take stillages. In order to prevent these from sliding on the corrugated sheet iron, a shock-absorbing mattress ensuring a perfect grip is placed between their flanged supports and the vehicle floor (following a suggestion made by a member of the depot staff).

Fig. 8. — Electric tractor.

An electric « distribution » tractor about to take over one of the rulleys of the site for outwards traffic. The wagons visible in the background are those standing on the first of the seven loading tracks (north shed).

Another four rulleys, finally, are specially designed and marked for the transport of dangerous goods so as to make it easier for the staff to observe the special regulations governing this traffic (another suggestion made by a member of the staff).

b) 58 three-wheel rubber-tyred electric tractors, with the single wheel leading (fig. 8), designed for a total load of 2.4 tons. The electric motor of these

machines is fed from two batteries, the routine exchange of which is carried out at the maintenance base whenever it is necessary.

Most of these tractors have a speed of 7 km (4 miles) per hour; the remainder, for reasons explained later, have a speed of 15 km (9 miles) per hour.

It is due to this traction method that one gets the impression of silence which surprises all visitors visiting the depot for the first time.

c) Very heavy packages are removed from the wagons by means of a mobile crane of 2.5 tons capacity, the boom of which is able to enter the inside of a covered wagon. Such packages are placed by the crane directly on one of the rulleys.

There is also a fork lift truck of 2 tons capacity which takes its load directly to the site concerned (sundries received or transhipped).

Moreover, 65 « roll-all » trolleys and 15 four-wheel « stores » type trolleys are provided specially for the bench of sundries received for local delivery.

Finally, the handling of pallets and palletised large consignments or loads calls for pallet transfer equipment. At present, the depot is equipped with twelve pallet trucks with a carrying capacity of 1 ton.

III. — SHUNTING ENGINES.

The drain and feed tracks as well as the loading and unloading tracks of the depot represent a shunting area of the station which is permanently served by two shunting engines, viz.:

— a Diesel locomotive which is used to prepare the incoming wagons for the unloading tracks of the south shed and to handle the outgoing wagons in the loading tracks of the north shed, as well as the transfer, in accordance with a prearranged timetable, of strings of incoming and outgoing wagons between the depot and the group of marshalling sidings;

— a 150 HP tractor, serving the tracks along the conveyors.

IV. — METHOD OF OPERATION.

Unloading of wagons.

The sorting of packages unloaded from the wagons is mechanised. As in other depots of this type, the unloading takes place on a conveyor (1), at the rate of one team of two men per wagon. The number of unloading teams varies according to the output required; at the end of 1954, four teams were employed.

The packages are removed from the wagon either by hand or by barrow, by means of rollers or low-floor trolley (2), according to their weight, and are placed on the conveyor with the label upwards.

Stillages are removed from the wagon on their wheels, in the travelling direction of the conveyor, with the aid of a special bridge placed between the wagon and the bench bordering the conveyor belt (this bridge was invented by two Lyons railwaymen and received a prize at a recent suggestions competition of the S. N. C. F.).

Pallets and large palletised consignments or loads are handled by pallet trucks, again making use of a bridge.

Package sorting begins at the last wagon of the string of wagons which are being unloaded. As the packages pass by on the conveyor, an official of the undertaking entrusted with the handling operations examines the labels of packages, stillages and pallets and marks them, using red or blue chalk on alternate

(1) As already mentioned, very heavy packages are loaded directly on internal movement vehicles which are placed at the wagon door on the cartway side. The same applies to important perishable consignments.

(2) This trolley, also known as « toad », can carry a load of 1 ton and can turn on the spot.

days, with a symbol indicating the working shift and one indicating the loading track (for transhipment packages) or section of platform (for packages received locally) to which the package concerned is to be directed.

In this first sorting operation, the packages are assigned to one of twelve portions :

— seven portions, each corresponding to one of the seven loading tracks;

— one portion for the cartage services (No. 10 platform);

— one portion for the part of the platform set aside for « sundries received for local delivery »;

— one portion for the part of the platform set aside for « small parcels and stillages »;

— one portion comprising those sundries received which are to be collected at the depot by well-known important firms; other packages to be collected at the depot are sorted out during the second stage of sorting, this time by a S. N. C. F. specialist, because of the great variety of addresses on these packages;

— one portion for dangerous goods or goods liable to cause contamination.

At the delivery end of the conveyor are lined up, as already mentioned, a number of internal movement vehicles, viz. :

— 40 (20 on either side) at No. 1 conveyor (fig. 4);

— 22 (11 on either side) at No. 2 conveyor;

— 20 (14 on one side and 6 on the other) at No. 3 conveyor.

The two rulleys standing opposite each other have the same destination so that unloading can continue without break, except in the case of No. 3 conveyor where the space available is not sufficient to permit a symmetrical distribution of the vehicles.

The packages removed from the conveyor are placed on these rulleys, generally in a single layer, with label on top. In the circumstances, the load hardly exceeds 800 kg per vehicle.

Small packages, placed in several layers on rack-type vehicles, add up to at least 600 kg per vehicle.

Stillages, pallets (in threes or fours), produce and tackle are loaded on the other vehicles available.

The supply of empty rulleys is ensured in such a way that there is always at least one vehicle available for each portion. The loaded vehicles are removed by the high-speed electric tractors known as « shuttle tractors » (1) and weighed as they pass over an automatic weighing machine of 6 tons capacity, placed at a point near the end of the bands where all vehicles must pass.

From that point onwards, the rulleys continue in different directions according to their destination.

Transhipment packages.

The rulleys carrying transhipments are taken to and left on a special parking area for transhipment traffic whence they are removed by the so-called « distribution » tractors (2) and taken to the loading wagons on each of the seven loading tracks of the north shed. There, the rulleys are lined up along the wagons to which their packages are transferred.

The intermediate parking of the transhipment traffic represents an essential element of elasticity which serves to smooth out any differences in the rates of output between the unloading site, with the conveyor belts, and the wagon loading site. It has, moreover, made it possible to confine the traffic between the two sites to that of the faster shuttle

(1) These tractors, twelve in number, travel at 15 km (9 miles) per hour and are merely manned by one driver, without carrying equipment.

(2) These tractors, travelling at lower speed, are described later.

Fig. 9. — Arrival of smalls. Checking before the microphone of a movable magnetophone.

The official is reading out aloud the name and address of the consignee shown on the label, as well as any other indications (payment on delivery, etc.) relevant to the preparation of the town delivery voucher.

type tractors, and that in the part of the depot where there was the greatest reason to fear traffic congestion. Originally, it had been planned to construct an underground passage to avoid the crossing of the flows of rulley traffic; with the organisation now adopted, this costly scheme has become unnecessary.

Smalls (up to 50 kg) and stillages received for local delivery.

The rulleys loaded with *smalls and stillages* are placed directly on the section of platform concerned. There, the packages are unloaded and sorted into zones for the town delivery rounds, placed on tricycles (which are so designed that they can also take pallets) and taken to their respective bays. When the indications on their labels have been read out aloud in front of a magnetophone (fig. 9), the packages are dumped until they can be loaded to the delivery vans.

The magnetophone coils are forwarded to the central office of the depot where they are monitored by a typist who prepares the issue vouchers for the carman.

Sundries of over 50 kg received for local delivery.

The rulleys concerned are taken, by their shuttle tractor, to another parking area which has the same purpose as that for transhipments, but which is only used if two or three conveyors are working simultaneously. It is also at this parking area that an S. N. C. F. sorting official carries out the second stage of the package sorting process by apportioning the

Fig. 10. — Checking of sundries with the aid of the loudspeaker telephone.

Microphone and loudspeaker of this instrument are located in the conical hood, seen to be suspended from a movable arm. Without having to face the microphone, the official calls out the legends on the labels which enable the official at the central office, at the other end of the line, to find the corresponding way-bill.

packages to the 18 Lyons town delivery zones (which comprise 13 rounds as well as direct deliveries to eight large department stores and industrial undertakings).

When the parking area is used, the rulleys are removed by distribution tractors and lined up along the enlarged (13 m) bench destined for this traffic (fig. 5). The packages are unloaded on the spot where they are checked and grouped in van loads, i.e. so arranged that they cover a surface approximately corresponding to the capacity of a delivery trailer. Checking is then carried out with the aid of a loudspeaker telephone (fig. 10), which permits two-way loudspeaker communication between the official at the bench who reads out the labels, and the official at the central office who is in possession of the corresponding documents. The loudspeaker telephones are mounted on trolleys so that they can be moved around as required. In this way, 19 such telephones cover not only the entire deck area but also 20 delivery trailers drawn up alongside so that it is also possible to check certain important consignments which are placed directly on these trailers whenever possible. In this case, it is unnecessary to set down and pick up from the platform. It is also for this purpose that the 65 « roll-all » trolleys and 15 stores type trolleys of this bench are used.

After checking, the van loads are loaded to the town delivery trailers in geographical order, with the aid of the issue vouchers sorted in this order by a cartage official.

A slightly different procedure is adopted in the case of consignments comprising several items which are still incomplete. These are not taken directly to the van load checking area but dumped at a « reservoir » area until they are complete. Partial delivery may, however, be decided upon by the official in charge of the traffic office if, in his opinion, commercial interests are involved.

The operating procedure adopted for these sundries differs from the one originally envisaged, and it is in this respect that experience has led us to modify quite considerably the methods developed on the basis of the working of comparable British goods handling depots.

To avoid one stage of the process, it had been envisaged to use, in this area, not a large deck area but a narrow bench which would simply permit of moving the packages directly from the rulley to the town delivery van (or trailer); the packages were then checked on the trailer itself, to which a set of loudspeaker telephones was connected.

This method was in fact used for several months but proved impracticable for a city as important as Lyons. To permit the checking of the packages in the trailer, the packages could, in practice, only be laid out in a single layer so that the payload of the trailer was considerably reduced. Moreover, the checking inside the trailer involved the risk of the packages being trodden on by the official. Furthermore, the packages had to be stowed in the trailer in the order in which they arrived from the conveyor, and not in geographical order of the roads served so that the town delivery was subjected to difficulties and delays. Finally, if the various packages of the same consignment happened to be separated on the conveyor they might find their way to different trailers, resulting in partial deliveries and in the need to inconvenience the client several times on the same day.

True, measures were taken to avoid the most irksome of these troubles, especially in regard to the last-named point. It was nevertheless, considered that the organisation ought to be completely remodelled. After detailed studies and cost price calculations of several alternative solutions, the method here described has been adopted since 1954. It differs from the original scheme in that a platform area has again been assigned for the re-sorting and checking of the packages prior to loading to the delivery trailer.

Experience has confirmed the advantages of this method compared with that of direct loading to the trailer: checking is easier; consignments consisting of several items can be kept together and delivered together (incomplete deliveries

have dropped to 0.6 %); packages are provided with proper documents (deliveries of packages without documents have dropped from 6 to 1 %); the trailers can be loaded in proper geographical order of delivery; last not least, the efficiency of the trailer service has been greatly improved.

The number of trailers used for the town delivery service has been reduced from 103 to 44, and the average tonnage carried by each trailer has been increased from 5.4 to 5.8 tons, taken over all the delivery rounds made by the trailer throughout the day. The comparison of these two results illustrates the improvement achieved in the utilisation of the trailers which now make, on the average, between two and three rounds a day, whilst they previously had to be kept at the depot for long periods to make up for the absence of a deck.

It is owing to this last-named advantage that the new method is more economical than the one formerly used. A very detailed cost price calculation has shown that, owing to the new method, the cost price per ton of sundries has been increased by no more than 10 francs to pay for the new deck, telephone installations, and a few additional trolleys, but that it has been reduced by 900 francs due to savings in trailers, tractors and staff for the town delivery service. On balance, taking into account certain additional savings arising from the fact that wagons need not be kept waiting on Sundays, the cost price has been reduced at the rate of 850 francs per tonne (1).

It may be pointed out that the additional section of deck is of a very modest size, no more than 13 m (43 ft) wide, and represents an intermediate solution between the original bench, which was merely a cartway for the transfer from internal movement vehicle to town delivery trailer, and the conventional type of deck where the packages are deposited prior to their being loaded to the vans, generally at predetermined times. Here, the packages are deposited only for as long as is necessary to check them and to remove those which are not yet ready for delivery. Loading to the trailer takes place immediately. To all intents and purposes, therefore, the clients receive their consignments with no more delay than with the narrow bench method.

It is our personal opinion that if, in the future, new mechanised depots are to be provided at important cities, such a staging platform would be the solution to be recommended for the local delivery of sundries.

Wagon loading operations.

The packages to be loaded on wagons departing from Lyons come :

— either from the transhipment parking area where the corresponding internal movement vehicles had been left waiting;

— or from consignments deposited by clients at the forwarding deck or collected from the in-town collection offices or collection round-trips.

The forwarding site where consignments are deposited by clients is equipped with four glazed cubicles (one for smalls, three for sundries). The packages are checked in the usual way, and the documents are despatched from these cubicles to the central office by means of pneumatic tubes.

As soon as the package has been properly labelled, it is loaded to one of the rulleys permanently lined up perpendicular to the deck. These rulleys are identical to those used at the ends of the conveyors. Numbering 77, they are arranged in groups of seven, each group being assigned to one of the seven loading tracks. Their loading must go on continuously, as the time spent by each package at this section of platform is strictly limited to the time required for checking and labelling.

(1) The mechanised depot has an annual traffic of about 26 000 tons of sundries of this kind.

As regards the packages coming from the in-town parcels offices or collection rounds, these are checked and labelled beforehand and carry an advance indication, provided by the in-town office or suburban station, of the loading track to be used. These packages can therefore be loaded on the internal movement vehicles without further formalities, simply by being passed on to the bench concerned, when leaving the town vans or collection vans.

The wagon loading method is the same, no matter whether the rulley is loaded with packages deposited at the forwarding platform or at the bench, or with transhipment packages coming from the arrival site and deposited in the parking area.

Each rulley is taken away by one of the 46 « distribution » tractors (fig. 8), which travel at a lower speed (7 km = 4 miles per hour) than the « shuttle » tractors and are equipped with a barrow and a loading bridge. The tractor-rulley combination is manned by two men, one driving the tractor, the other, staying on the rulley, deciding from an examination of the labels at which wagons to call.

The tractor passes along the wagons on the loading road for which the load on the rulley is destined, and stops in front of the different wagons for which the rulley carries packages.

The packages are transferred from rulley to wagon either by hand, or by means of the barrow or rollers, according to the weight of the packages. Small stillages, pallets or large packages and palletised loads are transferred by means of the loading bridge.

When empty, the rulley is taken back either to the forwarding platform, or to the bench, or to the transhipment parking area.

In the latter case, it is there picked up by one of the « shuttle » tractors bringing a loaded rulley.

All movements in the loading area are one-way workings. The average round-trip of a distribution tractor takes 23 min.

The average load of a rulley coming from the forwarding site is about 800 kg. The weight is ascertained by a second automatic weighing machine of 6 tons capacity, placed at the rear end of this site, at the end of the north shed.

The number of tractors required varies. It depends on the tonnage to be loaded, and varies from one day of the week to the other, and in the course of the same day. In principle, however, the tractors are allocated as follows.

One conveyor must be served by three « shuttle » tractors and ten « distribution » tractors (viz. two serving the enlarged bench for sundries received, and eight serving the wagon loading tracks from the transhipment parking area).

The site for sundries forwarded (section of deck and bench) requires on an average a fleet of five distribution tractors between 8 a.m. and 6 p.m., and a second fleet of 18 or 20 tractors of the same type between 2.30 p.m. and 10.30 p.m. (1).

V. — CO-ORDINATION WITH THE TRAIN SERVICE.

Figure 11 shows how, in principle, the conveyors are used during the three shifts of the day, on the basis of an hourly through-put of 21 tons, normally corresponding to the unloading of fifty wagons per eight-hour shift per conveyor.

In drawing up this theoretical scheme, it had been necessary to take into account, inter alia, the fact that during the afternoon, owing to pressure of work on the forwarding side, it is, in practice, impossible to use the third conveyor. For, at that time, the number of rulleys coming simultaneously from the tranship-

(1) This site for sundries forwarded is closed at 10.30 p.m. or, exceptionally, at 11 p.m.

Gare de Lyon-Guillotière

PLAN THÉORIQUE de DÉCHARGEMENT aux TAPIS des AFFECTATIONS REÇUES

Service du 3 Octobre 1954

HALLE MÉCANISÉE

(Trafic normal du Jeudi au Dimanche)

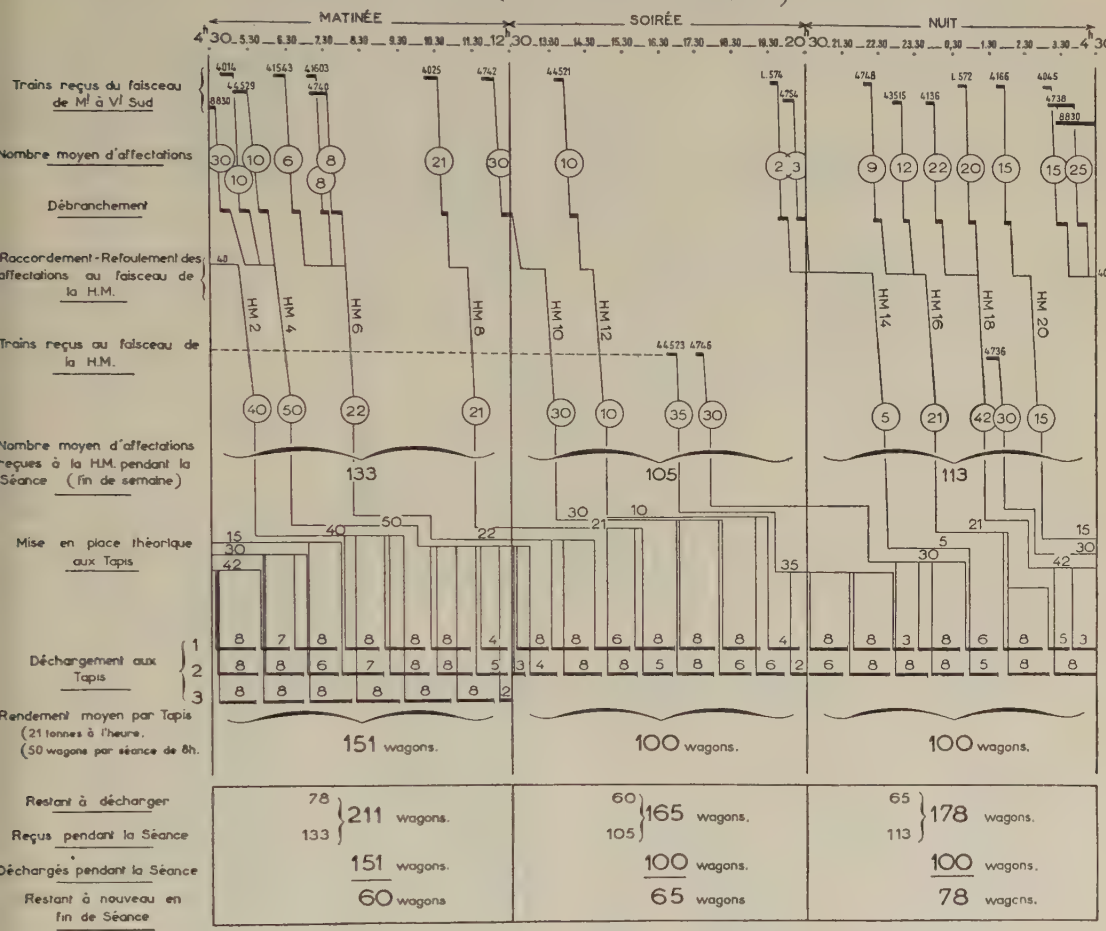


Fig. 11. — Working schedule of the three conveyors during twenty-four hours.

The figures represent numbers of wagons, the letters HM indicate a shunting operation between the sorting sidings and the group of sidings of the mechanised depot. The thin horizontal lines indicate the length of time during which the wagons remain in these sidings. The heavy lines shown against the conveyors indicate the length of time during which the corresponding unloading tracks are occupied by strings of wagons.

Translation of the other French legends of this figure (top to bottom):

Theoretical schedule for the unloading, at the conveyors, of regular wagons received.
Lyons-Guillotière Depot. Schedule of 3rd October, 1954.
(Normal traffic, Thursdays to Sundays.)
Morning. — Afternoon. — Night.
Trains received from Moulin à Vent sidings.
Average number of regular wagons.
Train splitting.
Re-marshalling and backing of wagons to the depot sidings.
Average number of wagons received at the depot during each shift (last days of the week).
Theoretical placing of wagons at the conveyors.
Unloading at the conveyors.
Average output per conveyor 21 t per hour, 50 wagons per 8-hour shift.
Remaining to the unloaded.
Received during the shift.
Unloaded during the shift.
Remaining to be unloaded at the end of the shift.

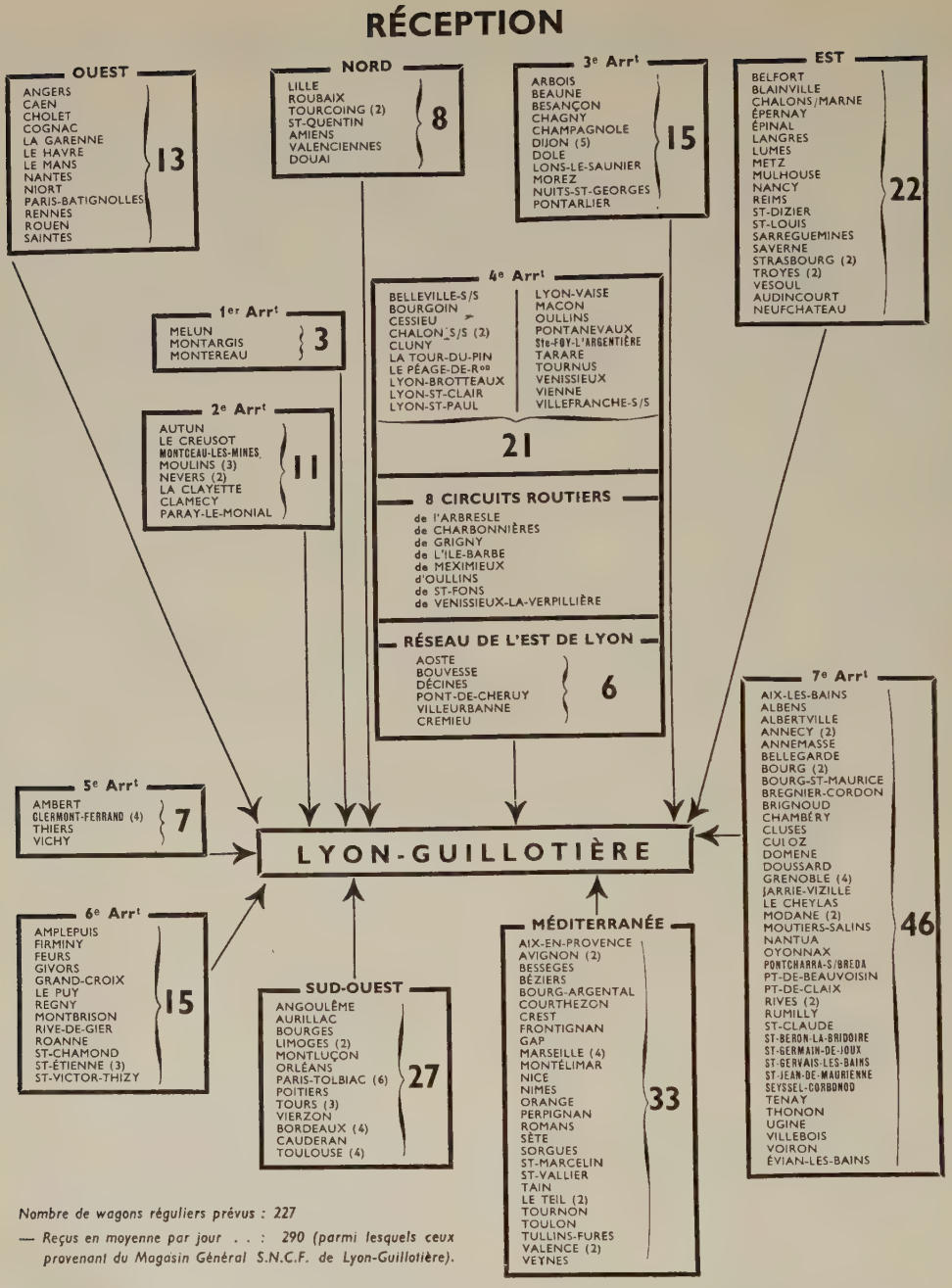


Fig. 12. — Origin of wagons and road vehicles arriving at Lyons-Guillotière mechanised depot every day.

Nombre de wagons réguliers prévus : 227 = scheduled number of regular wagons : 227 per day. — Reçus en moyenne par jour : 290 (parmi lesquels ceux provenant du magasin général S. N. C. F. de Lyon-Guillotière) = average number of wagons received : 290 per day (including wagons from the S. N. C. F. General Stores at Lyons-Guillotière). — Ouest = West. — Nord = North. — Est = East. — Sud-Ouest = South-West. — Arrt (arrondissement) = district. — Circuits routiers = road collection rounds. — Réseau de l'Est de Lyon = Lyons-East System.

ment and forwarding sites to the loading area would be so great that they would be in the way of each other. In practice, there should be no more than six or seven rulleys together in the loading area.

The diagram also provides useful indications for the scheduling of regional goods train arrivals. This timetable by which the depot is governed, must as far as possible ensure the complete utilisation, without sudden surges, of the unloading facilities available during each of the three working shifts.

Incidentally, as a result of repeated adjustments of train arrivals and also owing to an increase in the efficiency of the conveyors (1), it has now become possible to forego the use of the third conveyor during the night shift.

Figure 12 lists the wagons or road vehicles arriving at the depot according to their stations of origin. The total number of vehicles received regularly every day is 227 to which must be added an average of 63 optional wagons per day.

The withdrawal of the loaded wagons from the seven loading platforms is likewise governed by the freight timetable. Certain tracks are only cleared once a day, others three or even four times. The wagons are of course, marshalled in the order in which they are required in the train for which they are destined. Certain trains depart direct from the depot as soon as the engine has been coupled up and the brake test carried out, without any previous wagon shunting.

Figure 13 shows that the placing of the wagons on the seven loading tracks is governed by a very detailed plan, depending on the trains for which the wagons are destined.

Figure 14 lists, according to their stations of destination, the 229 wagons regularly despatched from the depot every day.

VI. — STORAGE OF PACKAGES ON SUNDAYS AND PUBLIC HOLIDAYS.

It is well known that, in the towns, the local delivery of packages is delayed on Saturdays and Mondays, since many industrial and commercial firms are closed, and that it is completely suspended on Sundays and public holidays.

This fact poses a problem to a mechanised depot which should, in principle, maintain a certain continuity of output. As a matter of fact, the unloading of wagons continues during these periods but in the absence of a platform with adequate reservoir capacity, at least for sundries of over 50 kg, dumping of packages on delivery trailers and internal movement vehicles must be resorted to.

For this purpose, we use, at Lyons-Guillotière, first of all, the 44 town delivery trailers assigned to the depot, then another 5 to 10 trailers assigned, during the week, to other cartage work but available on Sundays. The trailers thus loaded are kept inside the shed.

The remaining packages are then dumped on the section of the platform destined for sundries received. There is room for 44 van loads of checked and documented packages which need only be loaded on the trailers when they return empty from their first round on Monday.

Any packages still remaining are placed on the rulleys assigned to sundries received. If necessary, use is also made of the rulleys assigned to sundries forwarded, which are not required between 8 p.m. on Saturdays and 10 a.m. on Mondays.

(1) Efficiency has been increased from 18 t per hour at the outset to 22.8 t per hour at the end of 1954, although the type of packages handled is not particularly favourable in this respect.

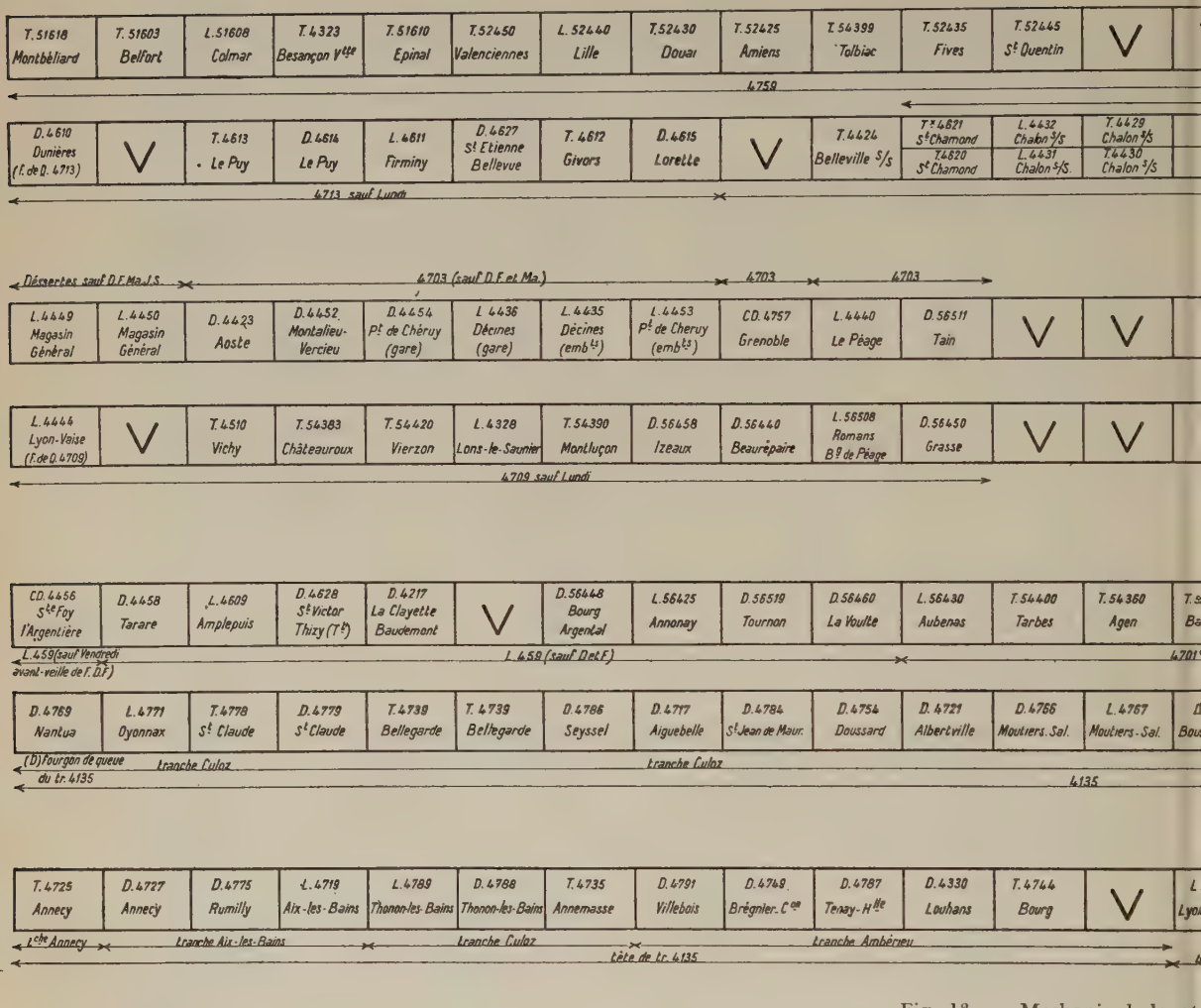


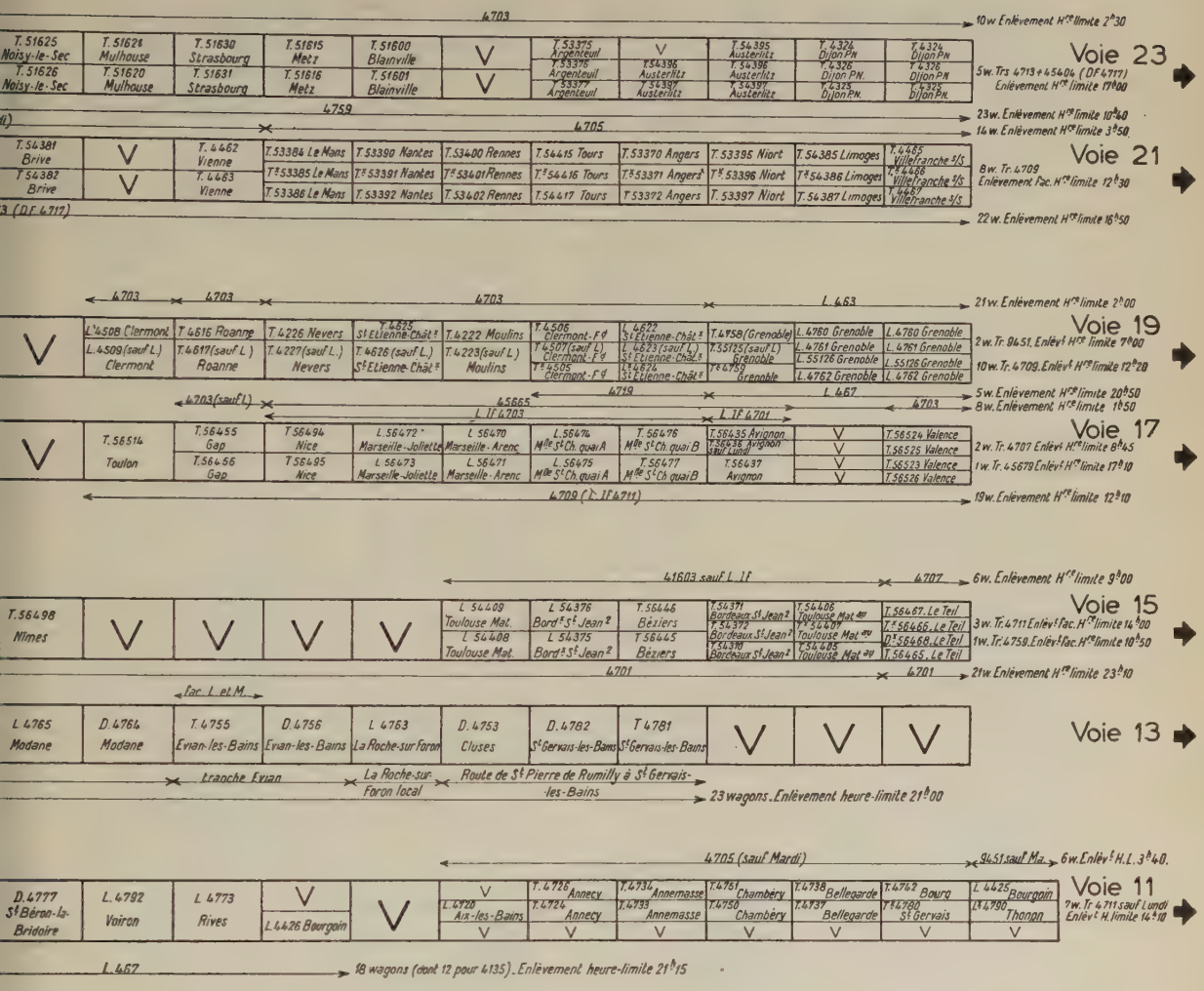
Fig. 13. — Mechanised depot

The plan shows how the wagons for the different destinations are marshalled on th to it in the sundries transports schedule of the French National Railways. Supe letter V indicates a berth available for optional wagons. The numbers shown is wholly formed at the depot, including its brake van, and leaves direct fo

Expl

Enlèvement heure limite... = departure not later tha

Before the stating deck for sundries received had been provided, it was necessary to leave some of the packages in the wagons loaded with sundries for Lyons locally. During periods of heavy traffic, 25 to 30 wagons were thus immobilised, pending unloading, from Saturday to Monday. This situation has been



ère. Wagon distribution plan.

tracks. Each oblong represents a regular daily wagon with the number allocated
gs indicate that the wagon berths concerned are used several times a day. The
ongs are train numbers. It will, for instance, be seen that Train 4135 (No. 13 track)

terms:
= Mondays excepted. — Tranche = group of wagons.

remedied by the provision of the new deck.

The magnitude of this weekend storage varies of course during the year. It amounts to about 300 t for an ordinary Sunday near the end of the year, and may reach, on the occasion of festivals, a figure close to 400 t, but this figure has not yet been exceeded.

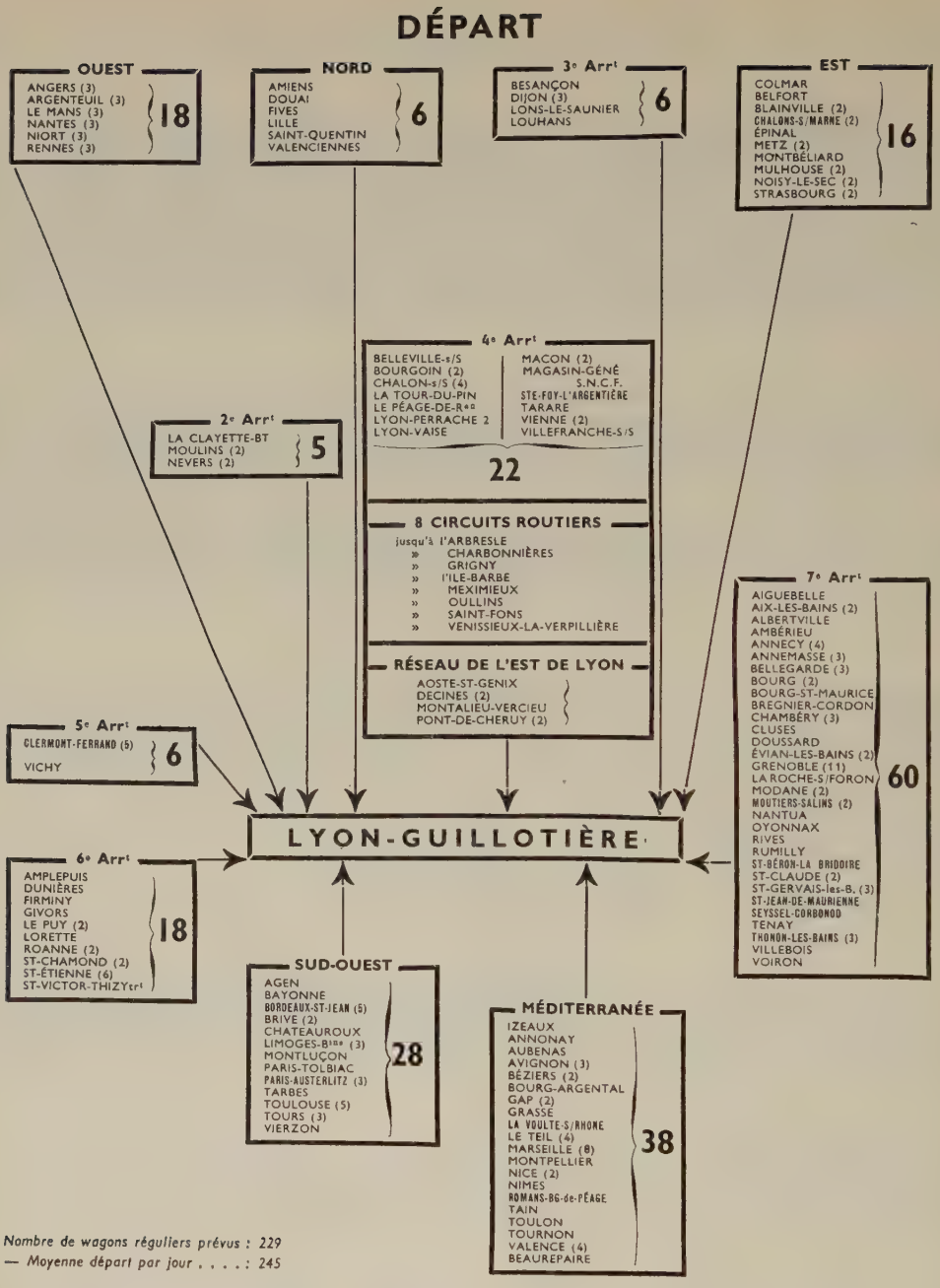


Fig. 14. — Destination of wagons forwarded daily from Lyons-Guillotière mechanised depot.

Explanation of French terms :

Nombre de wagons réguliers prévus : 229 = scheduled number of regular wagons : 229. — Moyenne départ par jour : 245. — Average number of departures per day : 245.

(Other legends as for figure 12.)

VII. — MAGNITUDE OF TRAFFIC HANDLED BY THE DEPOT.

In 1954, the traffic handled by the depot reached the following figures : 96 905 wagons were unloaded at the conveyors, 81 982 wagons were despatched from the loading area. Altogether, the mechanised depot thus dealt with 178 887 wagons in the course of that year.

This corresponds to an average of 490 wagons per day (including Sundays and public holidays). In fact, owing to the absence of local forwarding traffic on Sundays, the average per working day is considerably in excess of 500.

The corresponding tonnages are as follows :

275 603 t of sundries transhipped;
36 623 t of sundries received for the Lyons region;
58 441 t of sundries forwarded from the Lyons region.

The 36 623 t of sundries received are divided as follows between the three main groups :

— smalls and postal parcels (« smalls » section of platform) . . . . . 5 164 t
— sundries for local delivery (enlarged bench) . . . . . 26 200 t
— sundries for collection at depot (No. 10 platform) . . 5 239 t

Altogether, the depot has handled 370 667 t. The average daily tonnage has been 1 015; that on working days 1 048, divided between the different sites as follows :

sundries transhipped . . . . 755 t
sundries forwarded . . . . 193 t (1)
sundries received . . . . . 100 t

The unloading site (conveyors) has thus handled a daily average of 755 + 100 = 855 t.

The loading site (north shed roads) has dealt with a daily average (per working day) of 755 + 193 = 948 t.

During peak periods, these figures were considerably exceeded. The maximum tonnage for both sites together was reached on Friday, 2nd April, with 1 543 t of goods handled, divided as follows :

sundries transhipped . . . 1 146 t (2)
sundries received . . . . . 125 t
sundries forwarded . . . . 272 t

The maximum loading traffic (transhipped and forwarded sundries together) also reached its peak on that day, 2nd April, with 1 146 + 272 = 1 418 t.

For sundries received, the peak was reached on Thursday, 16th September, with 231 t, i.e. two-and-a-half times the average traffic.

It is thought that, on those days, the depot all but reached the maximum traffic which can be handled by the installations, the number of internal movement vehicles and the loading capacity of the wagons. The actual maximum traffic possible appears to be of the order of 1 600 t a day. If this is compared with the average traffic of, say, 1 000 t, it is apparent that there is a fairly high overload capacity.

A comparison of the tonnages and numbers of wagons illustrates the advantages of a high-efficiency depot such as Guillotière. Although the number of wagons received (96 905) was greater than the number of wagons forwarded (81 982), the tonnage forwarded was greater than the tonnage received, which shows that the wagons forwarded from the depot had a greater average load (4.2 t) than the wagons received (3.2 t). The difference exceeds 30 %, and that in spite of the fact that the number of wagons forwarded included a large proportion (20 %) of wagons with traffic for a number of wayside stations which nor-

(1) On working days only.

(2) On that day, the hourly through-put of the conveyors reached a figure of 23.5 t.

mally carry lighter loads than wagons carrying goods for a single terminus or transhipment depot.

Owing to this concentration and organisation of work, the despatch of some 25 000 wagons has been saved throughout the year, corresponding to a saving of 300 wagons which represent a capital of nearly 700 million francs.

It is interesting to note that this saving in rolling stock alone is only 100 million francs short of the entire cost of constructing the depot proper.

CONCLUSIONS.

Compared with the pre-war situation, the advent of the mechanised depot of Guillotière represents a concentration of the means at our disposal, with the following advantages :

— assignment to more useful purposes of large areas which have become available at stations in the Lyons region;

— major savings in staff due to the regrouping of the five sundries depots in the Lyons area;

— total or partial elimination of sundries transhipment traffic at stations sometimes remote from Lyons (Grenoble, Chambéry, Bourg, Bellegarde, Vienne, Roanne, Dijon) due to the concentration of this work at Guillotière, resulting in greater economy as well as acceleration of the traffic;

— finally, as we have seen just now, considerable savings in rolling stock.

Owing to these local circumstances, the mechanised depot has become, from a financial point of view, a highly economical proposition.

From the technical aspect, the depot, planned for a maximum traffic of 1 500 t per day, has reached the target and indeed exceeded it on occasions.

This result has not been achieved in a day. All the links in the chain of operations had to be tested and organised before arriving at the satisfactory working conditions encountered in the second half of 1954. In the light of experience, certain working methods had to be considerably modified as compared with the original plans. This was the case with the circulation of the internal movement vehicles, with the provision of parking areas, with the loading of sundries received on the road trailers, with the provision of the enlarged bench, and with the checking of the goods received which had to be carried out prior to loading to the trailers, and not afterwards as had been envisaged originally.

Similarly, the operation of the three unloading conveyors and the adaptation of their work to requirements in order to reduce the cost to a minimum had to be modified in the light of experience over a fairly long period. The choice of the most economical working methods has been facilitated by the elasticity with which it has been possible to employ the staff allocated to this site.

It is believed that the installations and equipment of the depot are now used to the best advantage; this is also due to a continuity of conception by virtue of the fact that the official in charge of the depot, M. JANOT, had been entrusted, from the outset, with the planning as well as the establishment of the depot.

Guillotière Depot represents, at present, the only French installation of such importance, dealing with the complete range of operations of a large sundries depot (sundries transhipped, received and forwarded) (1). In spite of this complexity, the depot represents a success, technically as well as economically. The impression of orderliness, silence, calm and regularity of output which amazes the uninitiated visitor, even on days with peak traffic, is a sure sign of such efficiency.

(1) The mechanised depots of Tolbiac and Noisy in the Paris area, comparable in size, are specially designed for transhipment and loading but do not deal with sundries received locally.

[625 .234 (43)]

Evolution of the lighting of passenger coaches on the German Bundesbahn, and in particular of modern lighting by fluorescent tubes,

by Walter Höer, Engineer, Dresden.

(*Deutsche Eisenbahntechnik*, January and February 1955.)

The historical evolution.

In the early days of railways, train lighting was as yet unknown. At first no trains were run when the light was beginning to go, and certainly not during the night. Such a situation naturally was eventually modified, but the general lighting of trains was still unthought of. Towards 1837, the higher classes of carriages were given a candle or oil lamp, one of which had to do for several compartments. Towards the end of 1844, the lighting of coaches was ordered in the case of the Prussian Railways and was achieved by the middle of 1846. The candles were replaced by oil lamps, which gave about three Hefner candle-power with the flat and seven Hefner candle-power with the round burner.

Gas lighting soon spread to the railway. First of all, attempts were made to use coal gas, transported in rubber balloons mounted under the body, then later on, on the roof, owing to the danger involved. As it was impossible to compress the coal gas, because this made it lose its lighting power, oil gas lighting was introduced in 1871. The gas was compressed to 6 to 8 kg/cm² transported in steel tanks under the body, and reduced by means of a regulator down to the correct pressure for use of only 30 to 80 mm of water. The two hole burner or slot burner was made of steatite and gave a light of five to six Hefner candle-power, according to the quality of the oil gas. The gas burners were lit from the roof. Acetylene gas with its great lighting power and simplicity of manufacture was too dangerous for use on the railway; in 1897, Julius Pintsch succeeded in appreciably improving oil gas lighting by adding acetylene to a proportion of up to 50 %. A mixture of three volumes of oil gas and one volume of acetylene gas which required no modifications to be made to the oil gas installations increased the lighting power to about 14 Hefner candle-power. One or several lamps were fitted in each compartment each with one or more jets. However, the great inflammability of acetylene gas in combination with the air led to several accidents; it was therefore only logical to try and use incandescent gas lighting on the railway when this was invented in 1884. Trials of this undertaken in 1894 failed because the mantle was soon destroyed by the vibration. No progress was made until the Auer inverted mantle, solidly attached to its fastening ring, was invented. The pressure of the pure gas could be raised to 150 mm of water, which considerably reduced consumption. It was then once more possible to use the cheap oil gas without any admixture. To light up, it was necessary to have a pilot light with its own pipe, which had the advantage of making it possible to cut the main pipe by means of a regulating cock to put out each lamp. The lighting power of the mantles then used was 35 to 60 Hefner candle-power.

Consumption which was two to three litres per burner with the mixed gas, fell to about 0.5 l when incandescent gas

lighting was used with a pressure of 150 mm of water. Increasing the pressure still further to 1 500 mm of water with so called incandescent lighting with compressed gas reduced the consumption to about 0.25 l per candle-power. The first installations of compressed gas lighting were put into service in 1913. Owing to the shortage of oil during the 1914-1918 war, it became necessary to go back to coal gas. The hope of being able to use coal gas permanently instead of oil gas could not be realised owing to its lower lighting power and its harmful components, which had a dangerous effect upon the gas compression installations and lighting equipment of the coaches themselves. In 1924, oil gas was therefore used again.

However, the development of electricity also made itself felt in the lighting of railway stock to the detriment of incandescent gas lighting. On coaches, where compressed gas lighting is still in existence — which represents about 2/3rds of all the coaches used on stopping trains — this will continue to be used. All the locomotives have already been equipped with electric lighting and the new coaches to be built will also be equipped with it.

The introduction of electric lighting on the coaches only took place very slowly on the Deutsche Reichsbahn, which had a very highly perfected compressed gas lighting system in which considerable capital had been invested. It was only owing to international complications due to the burning of an express coach with gas lighting when the railway accident at Bellinzona occurred on the 22nd April 1924, that the Deutsche Reichsbahn began the general introduction of electric lighting on its trains. At the present time, all the through express coaches, as well as one third of the other passenger coaches are equipped with electric lighting. According to the present reconstruction and new work programme, some years will still elapse before all the passenger coaches are equipped with electric lighting. The main advantage of the latter is undoubtedly the safety offered from the point of view of the risk of fires and explosions. Owing to the low voltage of the current used — 24 to 220 V — fires caused by short-circuits are practically impossible and have never occurred.

The first electric lighting installation on a German railway train dates back to 1882. The first trials took place on the Munich- Starnberg line at the time of the International Electricity Exhibition at Munich. In 1886, trials of electric train lighting were carried out between Frankfort-on-Main and Fulda and between Stuttgart and Immendingen with the « *Löbbecke and Oesterreich* » system. The speed of rotation and consequently the voltage were kept constant by means of a centrifugal regulator which moved a belt on two conical pulleys. Below a certain speed of rotation, the centrifugal regulator worked a switch and the battery fitted in parallel supplied current for lighting. In 1888, a train was equipped with electric lighting on the method devised by Professor *Dittrich* and ran between Stuttgart and Hall. On each coach there were two sets of accumulators, one of which supplied current for the lamps while the other was charging.

With all these methods, it was a question of the continuous lighting of the train, in other words a single generator for the whole train fed the batteries. As the incandescent lamps were fed solely from the batteries, the lighting obtained was absolutely uniform and steady. As the installations with a lighting dynamo did not satisfy them, in 1892, the Deutsche Reichspost began to fits its post office vans with lighting simply supplied from a battery. In 1895, trials were carried out on the Bavarian State Railways with individual electric lighting for each coach. The voltage was maintained steady at all running speeds by a heavy anti-compound winding. While the battery was charging a small resistance was inserted in the lighting circuit so that the lamps could burn at the same time.

In 1897, a first and second class express coach was equipped at Postdam with individual electric lighting on the *Stone* system (with a voltage of 24 V) in which for the first time the battery was charged at the same time as the incandescent lamps were supplied with current. When the direction of running was changed, the poles of the dynamo were changed over; the change of coupling was assured by a centrifugal regulator. As a result of these trials, 80 large post office vans were equipped with similar equipment which remained in service without interruption till 1929.

In 1901/1902, twenty-four series S 3 locomotives and fifty-seven express coaches were equipped with continuous electric lighting. On the locomotive there was a Laval 20 HP steam turbine running at 2 000 revs. per min. coupled to a generator through a reduction gear in the ratio of 1 : 10. The tension of the dynamo was 65 V for the lighting and 90 V for recharging the battery. In 1905, two express coaches were fitted with individual lighting using *Rosenberg* type dynamos with the armature keyed on the axle. The dynamo worked at constant voltage because of the shunting of the windings of the inductor and supplied the same current in both directions of running without requiring the inversion of special poles. In 1908, a few rakes lit by gas were also equipped with individual electric reading lamps of 50 V. A lighting dynamo driven by the axle was installed in the brake van; the current was distributed throughout the rake. However, these installations could not be put into service as the Bavarian and Saxon Railways did not equip their coaches with the necessary transmission lines. In 1910, a few new express coaches were equipped with 32 V lighting from accumulators. With this system, the batteries were recharged at the stations where the trains were made up and at the terminus stations. After 1913, all the new express coaches had to be equipped with electric lighting from accumulators, from which great savings were expected. Up to 1920, about 2 000 express coaches were as a consequence equipped with battery lighting, but were afterwards altered to take individual lighting from dynamos. As the batteries wore out in a relatively short time, difficulties were in fact experienced, especially when the coaches travelled into other countries.

The Bellinzona railway accident, on the 22nd April 1924, led foreign railway administrations to forbid the transit of German coaches lit by gas. The Reichsbahn was therefore obliged to alter all the coaches used for international services with gas lighting and equip them with individual electric lighting by dynamo. This work, carried out on 3 000 express coaches, was only completed in 1931.

In the same year the D. R. introduced *Pintsch-Grob* type electric lighting by dynamo on more than 400 express coaches. In this case the lighting current and the charging current are independent of each other; the constant tension of 24 V is regulated by purely electrical devices. Use is made of two batteries which are changed over after each stop. One of these is used to regulate the voltage, while the other is being recharged. This arrangement which in theory is the most perfect solution to individual lighting of coaches by dynamo had however to be given up owing to insurmountable difficulties in the construction of the electric regulating device. The standard type of the Deutsche Reichsbahn was used. In 1935, the German Railways decided that all new coaches would be equipped solely with individual lighting by dynamo. In the same year, trials were carried out of electric lighting by turbo-dynamo in the case of steam locomotives. The lighting voltage was 24 V.

From the economic point of view; it was very illogical to use at one and the same time several types of equipment the details of which varied considerably. The D. R. therefore decided to perfect its own

system and standardise it. They adopted a 24 V generator with shunt exciter and automatic voltage regulation, separate for the charging current and the lighting current. In 1931, the standard type adopted for the electric lighting of steam locomotives was the AEG turbo-generator of 0.5 kW. In addition, as an experiment, nickel-cadmium accumulators were used for the first time in 1929 to replace the heavy and delicate lead accumulators; as a result it was decided to equip all future passenger coaches with nickel cadmium accumulators.

In 1950, the German Bundesbahn in the American and British zones equipped 200 repaired coaches, mostly of the type used on through trains, with an experimental lighting by means of fluorescent lamps using A.C. current. About half were equipped with a 16 V 150 Hz convertor and a transformer supplied 220 V current for the lamps for converting the 24 V D.C. current. The other 100 were fitted with an individual undulator and transformers for A.C. 220 V 100 Hz current immediately before each lamp.

At the same period, the Deutsche Reichsbahn equipped some Metro coaches with low tension D.C. fluorescent tubes. With a tension of 800 V in the third rail, five tubes were fitted in series. The standard A.C. type of fluorescent tubes was used. It was necessary constantly to change the polarisation of the lamps. The next year the Deutsche Reichsbahn equipped one quarter of a Metro rake with high tension D.C. fluorescent tubes. Later on, these tubes were given a mercury reserve on the anode side to combat electrophorese. As a result it was now only necessary to change the polarisation of the tubes after they had been working for about 3 000 hours. Towards the same period, high tension fluorescent tubes with cold electrodes of 800 to 1 000 V were fitted on an express coach. A convertor transformed the 24 V D.C. current into 220 V 50 Hz A.C. current; each lamp was fitted with a transformer. In 1952, a new type was designed in which the 24 V D.C. current was converted into 440 V D.C. current.

In 1952, the lighting of the metro coaches was improved by fitting a special lighting fitting. The tubes were fitted with an aluminium band, oval in form, and fitted with enamel reflectors. The following paragraphs are devoted to the details of this evolution of lighting by means of fluorescent tubes.

The lighting of passenger coaches by fluorescent lamps.

General.

During the last war, various foreign railways had already fitted fluorescent lamps in their coaches. As most of these were only trials, the results obtained were contradictory; the total output was not much better than that of lighting by incandescent lamps. However, the experience acquired pointed the way to be followed. In studying the lighting of railway coaches by means of fluorescent lamps, the following considerations had to be taken into account :

1) Necessity to keep the lighting on even when the vehicles are stopped makes it essential to be able to store the electric power, which can only be done by having accumulators. The use of direct current makes it necessary to insert ohmic resistances in front of the lamps, so that there is an additional loss of current. With alternating current converters are necessary, which also consume extra current, make the installation appreciably dearer, and are very delicate.

2) The service regulations of the Deutche Reichsbahn stipulate a lighting of 35 to 50 lux in the middle of the compartment and about 26 to 30 lux in the corner seats and near the windows, measured one metre above floor level. However, this « minimum lighting » has been appreciably exceeded in all modern coach lighting installations in the interest of the passengers. It is only possible to

double the lighting in the different compartments with individual lighting of the coaches by using fluorescent lamps if the present power of the installation supplying the current is retained.

3) The high tension tubes (cold electrodes) which make a poorer use of the light than low tension tubes cannot be used for the individual lighting of coaches. Owing to the fact that with coaches with large compartments (through train coaches) the lighting equipment can be better distributed, from the technical lighting point of view, than in the case of coaches with small compartments, the total output is better.

4) None of the many trial fluorescent lighting installations already tried, often on a large scale, has proved itself to be the best.

The lighting of the Berlin Metro coaches by fluorescent tubes.

On the Berlin Metro, which is worked by 800 V D.C., the lighting of the coaches was obtained in the following way : the traction current supplied by the third rail was regulated to a constant voltage of 550 V by means of a voltage regulator with carbon plates, and fed 5 incandescent lamps of 110 V, 60 W, mounted in series. The lighting of the interior of the coach usually required four such circuits. Should the traction current be interrupted, an emergency lighting of four 5 W 6 V lamps is immediately switched on automatically. The recharching of the necessary battery took place permanently with the lighting being used.

This type of lighting was given up in the 1938 type coaches in which a converter took a nominal voltage of 48 V from a battery. All the incandescent lamps are mounted in parallel. In addition, they are mounted in such a way that should the current be cut off for short periods of not more than 4 sec. the lighting remains on and is only reduced automatically to 50 % at the end of this time.

Lighting by Metro type fluorescent tubes.

In 1950, the Metro central service began to use experimentally low tension fluorescent tubes in the 1927 type coaches. Five tubes, each 1 m long, were mounted in series and lit by a special lighting device. The light was 38 lux 1 m above the floor of the coach, and the consumption 560 W. Later on a special lighting transformer was installed by means of which the lighting up could take place from cold. In both cases, inversion of the polarity was necessary from time to time. The ordinary HN 120 A.C. fluorescent tubes made by VEB, Berliner Glühlampenwerk were used.

In April 1952, the Metro service was invited to equip 168 quarter rakes with low tension fluorescent tubes of a new pattern they had perfected. These are fitted as shown in figure 1. With this system only two lamps, 1 m in length, are mounted in series so that the principle of commutation purely at low tension has been given up.

One of each pair of tubes was arranged transversally across the body of the coach, which gave a better distribution of the

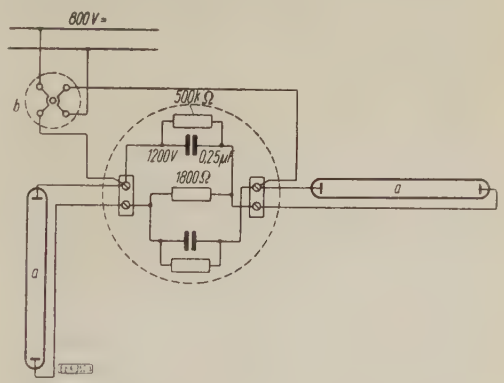


Fig. 1. — Diagram of the fitting of two fluorescent tubes 1 m long, in series with a capacity lighting up device for 800 V D.C.

a) HN 120 fluorescent tube.
b) Pole reverser.

lighting. However, the battery for the emergency lighting of the signalling lamps could not be charged on the train run; this had to be done by means of a fixed installation when the vehicles were not running. The resistances and condensers were mounted under a perforated cover fitted over the housing of the old incandescent lamps. To avoid partial darkening of the tubes due to electrophorese, these had to be constantly submitted to an inversion of the poles which was assured by a commutator.

The lighting was 80 to 90 lux 1m above floor level, i.e. exceptionally good. After they had been working for approximately 2 000 h, the light began to dim, probably due to the fluorescent matter for which zinc-beryllium was used in part. This drawback could be eliminated by the use of haluphosphate as the fluorescent material. Owing to the fact that low tension fluorescent tubes for A.C. of the ordinary commercial HN 120 type of the VEB Berliner Glühlampenwerk could be used, the capital cost was lower than that required for the Raw Berlin-Schöneweide system.

No figures are available regarding the lighting efficiency. However this appears to be greater than that of the high tension tubes used with the Raw Berlin-Schöneweide system.

Berlin-Schöneweide type.

The Berlin-Schöneweide repair shops in collaboration with the VEB Glaswerke Ilmenau and the VVB Westglas Ilmenau fitted one quarter of a Metro rake, as a trial, with high tension fluorescent tubes for direct current, 50 cm long, of special design, fitted with a special cathode and special auxiliary lighting up. Here again the poles of the tubes had constantly to be reversed. As a result of the observations made on this trial installation, a type 1927 rake was fitted with fluorescent tubes of a modified design. Each incandescent lamp was replaced by a special 50 cm long tube (fig. 3) in series with a resistance and a condensor (fig. 2); the installation worked perfectly.

The characteristics of figure 4 show the variation in the electric values of these tubes. If the working point A of the tube is put at 90 mA, by tracing the straight line representing the resistance

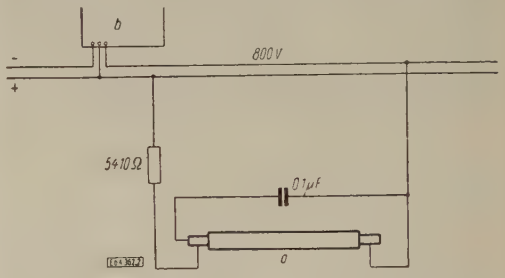


Fig. 2. — Diagram of the fitting of a high tension fluorescent tube, 800 V D.C.

a) Fluorescent tube.
b) Distribution table.

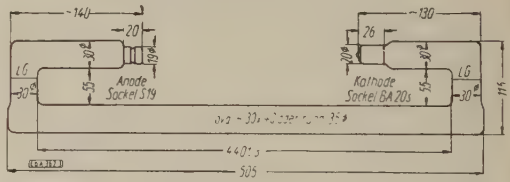


Fig. 3. — High tension type G. 505 fluorescent tube of the « V E B Glaswerke Ilmenau » of the « V V B Westglas Ilmenau », special type for Berlin Metro.

LG = limit of the fluorescent devices.

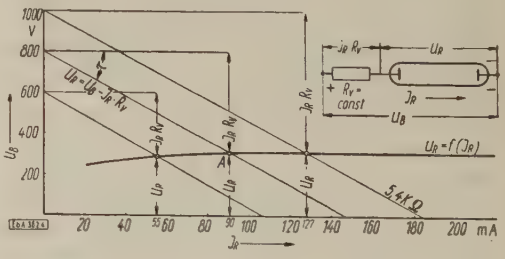


Fig. 4. — Characteristic of the Westglas fluorescent tube for D.C. type G. 505 of the « V E B Glaswerke Ilmenau » of the « V V B Westglas Ilmenau », special type for Berlin Metro.

which should pass through the centre point of the ordinates corresponding to the nominal working voltage (800 V), it is possible to determine the value of the resistance R_V to be inserted in series with the tube. R_V is represented by the angular coefficient of the straight line of the resistance : $R_V = \text{tg } \tau = U_B/J_R$.

To determine the way in which, on a given curve, a variation in the working voltage U_B is reflected in the characteristics of working of the tube, a parallel translation must be made of the straight line of the resistance so that it passes through the centre point of the ordinates corresponding to the new working voltage. If for example, the working voltage falls to 600 V, the intensity of the current in the tube is still 55 mA.

In practice it became apparent that a definite dissociation takes place after about 10 h working. To date the polarity of the tube has been reversed within this time limit. To avoid the repercussion of electrophorese and inversion of polarity of the tubes, the VEB Glaswerke Ilmenau have designed a tube which has a sufficient reserve of mercury on the anode side so that there is never any lack of mercury ions during the useful life of the tube (see fitting, fig. 5). This has made it possible to make the visible dissociation coincide with the life of the tubes. During trials covering more than 3 000 h of working, without inversion of the poles, no sign of one-sided dimming was noticed. The reduction in the luminous flux at the end of this time was about 17 %, and this was due to the reduction in the luminous effect of the fluorescent matters. Doing away with inversion of polarity during working also makes it possible to recharge the battery for the emergency lighting of the coaches in the usual way without supplementary installations.

The battery is recharged on the lamp circuits. The lighting of the signals is assured by the current from the third rail with a fixed resistance inserted. During service trials of this experimental installation, the lighting measured one metre above floor level was 68 lux on the average. Lighting by high tension direct current fluorescent tubes was divided up in four circuits, each of five tubes, successive tubes being included alternately in different circuits. In this way, should any damage occur, light of sufficient

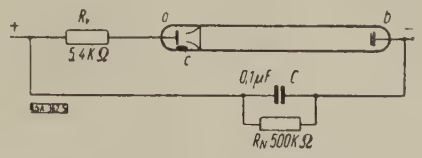


Fig. 5. — Lighting up diagram of Westglas D.C. fluorescent tube of the « V E B Glaswerke Ilmenau » of the « V V B Westglas Ilmenau ».

a) anode; *b*) cathode; *c*) mercury reserve.

uniformity is still available. As the tubes were mounted in parallel, failure of any one tube does not put the whole circuit out of action.

The technical characteristics of this type of lighting are as follows :

Consumption of current :

0.09 A per tube;
0.45 A per circuit;
1.80 A per coach.

Voltage :

300 V for a voltage of 800 of the traction current.

To determine which was the most economical method of lighting, the most certain, and the most suitable, the two types : with ordinary A.C. low tension tubes, and with special D.C. high tension tubes, were subjected to extensive trials.

The Metro Central service in 1951 equipped eight coaches with its own system. The Berlin-Schöneweide repair shop up to the end of 1951 equipped 50 coaches with special fluorescent tubes, twenty being 1938 type coaches and thirty 1927 type.

In order to ascertain the behaviour of

the high tension tubes should the voltage fall, the deadman's handle device of a braked trial rake on a suburban train was worked on starting up. In this way, the traction current voltage fell to 450 V. Even with this voltage which is exceptionally low, all the tubes lit up perfectly with the exception of one from which the condensor had been omitted for trial purposes. This proved that even with abnormally low voltages, D.C. fluorescent tubes will light up and burn without difficulty.

In 1952, the Berlin-Schöneweide repair shops equipped some further 1938 type coaches, retaining the 48 V battery. With this arrangement, the battery is no longer charged in series with a fixed resistance but on an auxiliary circuit.

As we have already said, only ohmic resistances can be used as regulating equipment in series with lamps discharging in the gases working on D.C. Trials are in hand to replace resistances with a metal wire by iron-hydrogen resistances, which will make it possible to maintain the luminous characteristics of the tubes constant in spite of very wide voltage variations. Figure 6 shows the variation compared with the curve of the luminous flux

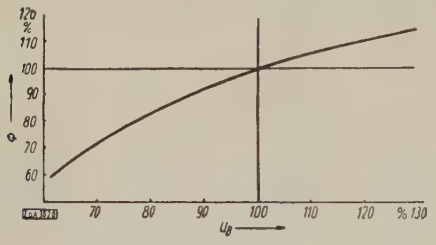


Fig. 6. — Approximate curve of the intensity of the lighting current in terms of the working tension when a iron-hydrogen resistance is used.

in terms of the voltage when iron-hydrogen resistances are used.

To make sure the tubes light up properly even under the lowest voltages, close to 450 V, a special lighting fitting designed by the VEB Glaswerke Ilmenau (fig. 5) has been used. Here lighting up takes place by capacity effect. When the circuit is closed, an auxiliary anode placed close to the cathodes receives a voltage impulse through the capacity C. Owing to the voltage of the important field between the cathode and the auxiliary anode a luminescent discharge occurs here which causes a preliminary ionisation of the gases and primes the lighting. It is therefore not necessary to use for the lighting either an inductance which gives a high voltage impulse, nor any other complicated technical device. At 450 V, lighting up takes place perfectly; even at a voltage as low as 420 only a few isolated failures were noted.

In addition to the round tubes, an oval fluorescent tube has also been tried incorporating an enamelled reflector. By this means the light could be increased by about 30 %. In 1953, during trials to perfect the equipment, the condensor for lighting up was given up and replaced by a band of a mixture of graphite applied to the tube and covered by a coat of insulating varnish. The last trials succeeded in getting perfect lighting up at as low as 360 V. This made it possible to mount two tubes in series as in the Metro system. However the well known drawbacks of mounting in series led to the giving up of this solution.

The technical characteristics of fluorescent tubes of the D.C. type G 505 are as follows :

Traction voltage . . .	U_B = 800 V
Current working the tubes	J_R = about 90 mA
Voltage at which the tubes work	U_R = 310 V
Lighting up voltage . .	U_Z = about 450 V
Resistance in series . .	R_V = 4.5 kΩ
Power of the tubes . .	N_R = 27 W

The tubes in one quarter of a rake used a total current at nominal voltage of 3.6 A, in other words the power is 2.8 kW.

The trials are being continued and the VEB Westglas has just designed a U shaped tube which is covered by a glass deflector in the coach. As the length is nearly doubled in this way, for an equal number of tubes, the lighting is also doubled.

Financial considerations.

One quarter of a 1927 type rake lit by incandescent lamps consumes 0.5 A per circuit, the regulator 0.2 A, i.e. with five circuits per coach, 5.4 A per quarter rake, including the signal lights, with full lighting.

With D.C. tubes the consumption amounts to a total of 4.3 A, i.e. four circuits of 20 tubes in the motor unit and of 22 tubes in the trailer, using 0.09 A per tube, plus 0.5 A for the signal lights. In this way, besides double the amount of light, there is a saving of current of 1.1 A, i.e. in round figures 20 %.

In the 1938 type lit by incandescent lamps, the converter which supplies all the lighting and charges the battery consumes 8 A. The saving in this case, for double the amount of light, being 3.7 A i.e. a saving of about 45 %. But as any judgement of a lighting installation must be based upon its luminous efficiency, quite different results are obtained.

The measurements made in the VEB Mechanik Gaselan Berlin Laboratory on the U shaped high tension tube, with cold electrodes, show that with an average working current of an intensity of 90 mA, there is only a luminous efficiency factor of 14 lm/W, i.e. taking into account the resistance mounted in series, a luminous efficiency at this voltage of 61 lm/W. This lighting is therefore less economic than lighting by incandescent lamps which gives 10 lm/W at the same working voltage.

The decorative and lighting effect of the Berlin-Schöneweide arrangement is particularly good. The small 50 cm tubes fit into the coach very well and the lighting is practically uniform throughout the coach. This is why the idea of using straight tubes which would be expensive to manufacture has been given up.

The fitting of fluorescent tubes in passenger coaches.

The studies were made by the Delitzsch repair shop. In 1950, the *Lüddicke* working group was formed in this establishment, to which the engineer *Schüler,* the technical manager of the shop belonged, their job being to design individual lighting for passenger coaches, capable of standing up to the difficult railway conditions and of meeting modern requirements. In 1951, after laboratory tests, the work was so far advanced that it was possible to fit out an express coach with individual lighting. The usual type of dynamo was used to generate the current, built in series, producing 24 V D.C. A battery of accumulators was mounted in parallel with this dynamo. A commutator transformed the direct current into alternating current at 220 V, and a transformer-booster was fitted before each lamp which increased the voltage from 800 to 1 000 V. The installation included high tension fluorescent tubes for alternating current, curved in shape and fitted with cold electrodes. Curved tubes were used in order to obtain the rational lighting equipment corresponding with the shape of the compartment. This coach ran in normal service on different lines without giving rise to any criticisms.

The photometric measurements gave the values collected together in Table I.

The two series of measurements were made with the same working voltage. Whereas the reduction in lighting in the compartments with pinkish white or white tubes remained low and must be attributed to a large extent to the obscurity due to the compartment walls, the compartments fitted with white-yellow fluorescent tubes gave an extraordinary reduction in

TABLE I. — **Results obtained by lighting measurements.**

Compartment	Colour	Light in lux		Measuring point
		on the 18-2-51	on the 13-9-51	
3rd class	pinky white	25	24	1
		31	25.5	2
		26	21	3
3rd class	white	24	24	1
		35	28	2
		28	23	3
2nd class	pinky white	53	50	1
		66	58	2
		54	50	3
3rd class	white-yellow	33	15	1
		41	17	2
		34	14	3
Toilets	white	40	31	1

lighting. Phenomena of the same kind were also observed in the case of fixed lighting equipment using fluorescent tubes of the same colour. These two tubes were therefore replaced by pinkish white tubes. The current consumption varied between 49 and 63 mA.

The capital cost and working loss of this first trial installation were relatively high. This first design was therefore given up, and after new trials, a second type was designed using direct current. The 24 V current produced by the ordinary lighting dynamo was converted to 440 V D.C. and the electric power thus produced was stored in a 24 V nickel/iron battery type NC 120.

The lighting of the passenger compartments and adjoining parts of the coach were assured by oval fluorescent tubes with enamelled reflectors, the diameter of the tubes being 38 mm and the colour yellow or whitish-yellow, 0.5 and 1 m in length, arranged at right angles to the longitudinal axis of the coach. Photometric measurements were made during a series of trials. The results are given in Table 2 (see also fig. 7).

TABLE II. — **Light measurements.**

Measuring point	1. Measure (whilst running)		2. Measure (whilst running)		3. Measure (whilst stopped, supplied from battery)	
	Strength mA	Lighting lx	Strength mA	Lighting lx	Strength mA	Lighting lx
1	70	34	65	32	25	13
2	70	15	65	15	26	6
3	68	17	65	15	25	6
4	68	17	65	15	23	6
5	70	19	65	17	27.5	7

Unlike the experience with the first trial coach, the regular lighting produced by the D.C. tubes gave a very agreeable impression. The total output of the tubes supplied with direct current was about 20 % higher than that of the A.C. lamps.

The superiority of fluorescent tubes over incandescent lamps was already obvious with this installation, but the inconvenience of the necessary overvoltage still remained. During investigations that had been completed, the Delitzsch repair shop carried out trials which made it possible to lower the lighting-up voltage of the tubes from 800 to 320 V per metre length of tube, and the working voltage had been lowered to 200 V.

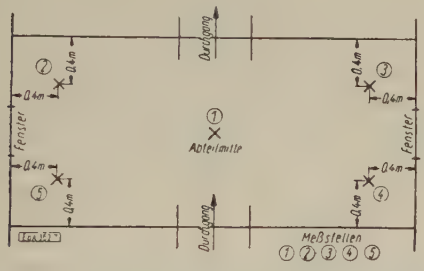


Fig. 7. — Sketch of the photometric measurements in a compartment of the C 4*i* 72644 Halle coach.

N. B. — Abteilmitte = middle of the compartment. Durchgang = corridor. — Fenster = window. Messstelen = measuring points.

As a result of these trials, a new arrangement was tried out in service on a third coach, using as generator a lighting dynamo rewound in such a way that it supplied 85 V D.C. and fed an 85 V battery of accumulators. The lighting fittings used were the normal A.C. low tension type HN 50 fluorescent tubes, 470 mm long, fitted on the outside with provisional lighting up bands. The fitting involved a special lighting up battery, an iron-hydrogen resistance as stabiliser and the usual ohmic resistances. In addition, to assure the constant voltage of the dynamo, a suitable field regulator for these tubes was provided. There was no lighting up by discharge device to assure the preliminary heating of the electrodes, as is usual with low tension fluorescent tubes. To avoid return currents, cells with blocking liners were inserted in the circuit. Lighting up was assured by a special 300 V battery and by the lighting band with which each lamp was equipped. Figure 8 shows the assembly.

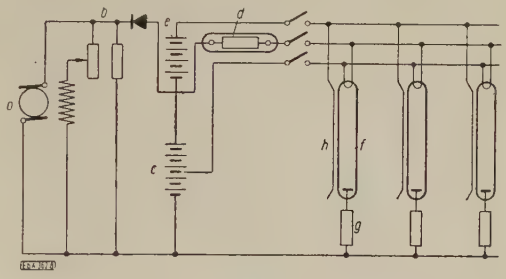


Fig. 8. — Fitting diagram for train lighting by 85 V D.C. fluorescent lamps on the Deutsche Reichsbahn. Trial coach BC 4*i* Halle 33147.

a) 85 V D.C. lighting dynamo.
b) Field regulator.
c) 85 V 30 Ah battery.
d) Stabiliser (resistance Fe-H).
e) Lighting up battery 300 V.
f) Low tension fluorescent lamp HN 50, 250 mA.
g) Resistance.
h) Lighting band.

This trial arrangement has given the best results to date in continuous service. Although no special reversing switch was fitted and the train staff do not have to bother about pole changing during the run, no dissociation of the gases nor premature wear of the anode has occurred. It is merely necessary for the fluorescent tubes to be turned in their sockets when the periodic overhauls are made every month. The luminous coefficient of efficiency and consequently the output were higher than with incandescent lamps. The output reached about 0.8.

In spite of this remarkable success, the *Lüddicke* working group did not stop at this. In collaboration with the VEB Gaselan of Berlin, and the Karl Möser

Company, of Halle, they designed a new fitting, which is shown in figure 9. There again a tension of 85 V has been used. The D.C. generator, with a power of 850 W is mounted in parallel with a battery of accumulators. As heretofore with individual lighting of the coaches, the current is supplied to the lamps by means of a carbon element field regulator

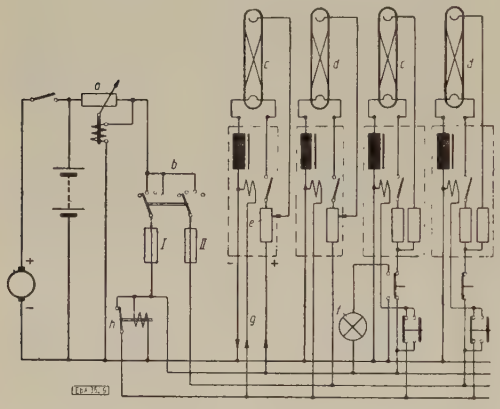


Fig. 9. — Connections for low tension D.C. fluorescent tubes, with and without individual commutation of the tubes. Type 1953.

a) Lamp regulator.
b) Main commutator.
c) Circuit I.
d) Circuit II.
e) Ohmic resistance.
f) Pilot lamp (blue).
g) Lighting up current.
h) Time relay (time lag : 1.5 sec).

intended to assure the voltage of the generator remaining constant, as well as a regulator with carbon plates assuring the voltage of the lighting system remaining constant. Beyond the chief lighting switch there is a time relay which works after 1.5 sec. when the compartment switches are worked. The increase in voltage caused by the working of the switch, in conjunction with the action of the delayed action relay is sufficient to heat the electrodes and light up the fluorescent tube. Here again, apart from the reactance coil and ohmic resistance, no lighting up by discharge is necessary.

The development of fluorescent lighting on the Deutsche Bundesbahn.

In 1950 the Deutsche Bundesbahn decided to equip with fluorescent lighting two hundred rebuilt coaches, mostly of the type used on the through trains, as well as thirty through train coaches and ten new express train coaches. The type of current adopted was 220 V, 100 or 150 cycle, A.C. As the usual generator and 24 V battery were used, it was necessary to convert the direct current to alternating current.

The installations in the rebuilt coaches.

One hundred coaches for through trains were fitted with a converter to convert the direct current which supplied 16 V A.C. at approx. 150 Hz. The other hundred were equipped with individual undulators (Zerhacker) immediately in front of the fluorescent lamps. The low tension alternating current was raised to 220 V by means of a transformer supplied with each tube. The cycles of 100 or 150 were selected to avoid the wavering effects which are visible to sensitive eyes with 50 Hz.

As the original idea was to reduce to the minimum the installation costs and consequently to limit the power of the generators and accumulators, it was not possible to improve the lighting in the compartments as is possible with a higher coefficient of luminous efficiency of the fluorescent tubes. The lighting obtained, 25 to 30 lux, was not much better than that given by incandescent lamps. After further study a tension of 220 V was adopted for the lines of the system. In addition, instantaneous lighting up of the tubes which had been required at first was given up and a central undulator adopted, the output of which is better. The resonance mounting was retained, although the instantaneous lighting up, this makes possible, was no longer required.

Resonance mounting gives very rapid lighting up, even with practically cold electrodes, which submits them to considerable fatigue and reduces the useful life of the lamps. In addition, the condition of resonance can only be obtained by a given state of functioning. But, owing to the tolerances of the condensors and induction coils, as well as the fluctuations in the voltage of the system, variations in the working values are of particular importance. Another drawback of resonance mounting is that the values of the voltage of the relighting points are appreciably higher with this system than with discharge lighting up mounting. This leads to considerably greater fatigue of the electrodes, which leads to a reduction in the useful life of the lamps. The mounting in which special heating transformers are incorporated to assure constant preliminary heating up of the electrodes also involves overloading the electrodes and lamps.

The installations in the new coaches.

The voltage system used in the new coaches is 220 V. The main constructional details provided for were : a lighting dynamo of 24/30 V 70 A, a 180 Ah accumulator, a converter to change the 35 A 25 V D.C. into two phase 16 V 150 cycle current, two transformers 16/220 V, 150 Hz. The 24 V direct current supplied by the generator or the battery is converted into 16 V 150 cycle alternating current and the voltage raised to 220 V.

Above the lighting fittings which are arranged transversally in the coach have been placed the auxiliary devices which fit into recesses made in the ceiling where they are invisible. The original intention was to standardise the use throughout all the compartments of the forty coaches of HNW-202 lamps, which consume 40 W but this idea had to be given up; it could only be managed in the thirty coaches for through trains. The limited power of the converter made it impossible to install HNW-202 lamps in the compartments of the express coaches. These were therefore fitted with only 25 W fluorescent lamps. Even with these however a minimum lighting of 80 lux was possible.

To make these lamps pleasant to look at, they were covered with unpolished plexiglas; only the coaches delivered in July 1951 were fitted in their second class compartments with lamps covered with clear plexiglas.

The essential difference between the lighting installations of the rebuilt coaches and those of the new coaches lies in the use of a lighting up device by special discharge. With this fitting, the lamps light up immediately the circuit is closed; it happens however that sometimes they go on and off at first several times, so that they only really light up after 2 or 3 sec. It was this unpleasant phenomena which led to the adoption of the resonance fitting which gives instantaneous lighting. Experience acquired in service after more than a year shows however that the objections raised to the fitting with lighting up by discharge were not well founded.

The useful life of the fluorescent lamps has exceeded all expectations. On the forty coaches for through trains put into service in July and August 1951, no lamps had had to be replaced by the middle of May 1952. The mileage run by these coaches varied between 70 000 and 143 000 km (43 000 and 89 000 miles). On eleven other coaches, only ten lamps had to be replaced over a ten month period in the passenger compartments and seven in the corridors and toilets. The wear is therefore only 0.83 lamp per 100 000 km (62 000 miles) run in the case of the compartments and 0.53 in the case of the corridors. In another group of newly constructed vehicles after a total mileage of 595 000 km (366 000 miles) no lamps had had to be replaced in the compartments. In only one of these coaches two lamps had

to be replaced, which represents a wear of 0.336 lamp per 100 000 km run. These favourable results, noted in the stations and the different maintenance shops, are an impressive demonstration of the quality of these lighting installations and the value of fluorescent lighting. The lighting up difficulties, which sometimes occur under certain climatic conditions with lamps with resonance fittings, have not been experienced in the newly built coaches.

Special types of lighting installations.

Whereas the lighting installations described above generally correspond to the normal types, that perfected by the firm of Krupp is on entirely new lines. The production of current is assured by an auto-excited three phase generator, with the excitation winding fed through a rectifier. Part of the three phase current thus produced is sent through the lighting system, and another part supplies the battery through the intermediary of a dry rectifier. The generator and the battery are mounted in parallel. Thanks to these special arrangements, the charging current remains appreciably constant throughout the whole time the battery is being charged.

This lighting installation was fitted on certain trial coaches equipped with fluorescent lamps. The conversion of the current from the battery into alternating current to light the coaches during stops is done by means of a rotary converter. To make the current passing through the lamps independent of voltage fluctuations, in addition to the stabiliser coil, a coil with differential premagnetisation has been fitted at each lamp. Thanks to this arrangement the current passing into the lamp remains constant between voltages of 180 to 350.

Arrangement of the lamps and lighting results obtained.

The choice of the arrangement of the fluorescent tubes which on account of their straight shape and length of 0.47 to 1.20 m can be fitted either longitudinally or transversally in the coach, was preceded by investigations into the most suitable arrangement. In most of the rebuilt coaches, the lamps in the passenger compartments were fitted without any shades to the ceiling of the coach, longitudinally above the centre corridor, at the point of intersection of the centres of the bays and the centre of the coach. Between the ends of the tubes covered with plexiglas are gaps of from 0.4 to 0.6 m long which have been filled in some coaches with imitation lamps so as to give the appearance of a continuous line.

Systematic measurements have made it possible to determine the lighting in the compartments and at the seats with three different arrangements of the lamps : central arrangement with one lamp in the longitudinal direction, transversal arrangement of one lamp on the centre line of the compartment, and parallel arrangement of two series of lamps longitudinally.

In coaches with large compartments, the distance from the window seats to the source of light is at its maximum when the tubes are arranged longitudinally in the centre of the ceiling. The transversal arrangement has the advantage of bringing the source of light nearer the corner seats by the windows. However, the arrangement which assures the best distribution of the light throughout the coach and gives the maximum lighting to the corner seats and on the walls of the coach is that in which there is a double series of longitudinal fittings arranged above the seats. But this arrangement is more costly to install and maintain.

The measurements of the lighting were usually made at reading level (1 m above the floor, 0.4 m from the back of the seat). To date a light of a least 40 lux has been required at this point in all classes; in January 1951, the Deutsche

Bundesbahn increased this value to 80 to 120 lux on its coaches. The average values for a compartment were obtained by means of two series of measurements carried out above each row of seats. In the end compartments, the lighting was on the average about 8 % lower than in the centre compartments.

The measurements showed that it was impossible to obtain the desired lighting of 80 lux in the through train coaches with 25 W lamps with or without a plexiglas covering, no matter how the tubes were arranged. This amount of light could only be obtained with 40 W. The fundamental difference in the lighting with the transversal and longitudinal arrangements was very marked. The reduction in light due to the presence of luggage is appreciably less when the tubes are arranged transversally in the compartment.

In the express coaches, the installation in isolated compartments of 40 W lamps for 220 V 150 Hz current, with plexiglas covering and arranged parallel to the longitudinal centre line of the coach gave the desired 80 lux; in the corner seats even 107.3 lux was obtained, 132.3 lux in the centre seats, and the average was 119.8 lux.

The lighting above the corner seats, when there was no luggage, was 3.8 % higher when the light fittings were arranged longitudinally than when they were arranged transversely. In the centre seats, there is no noticeable difference. The difference is on the average 1.6 % in favour of the longitudinal arrangement. However, this slight improvement in the lighting is not attributable to the arrangement of the lighting fittings but to the way they are made. The plexiglas covering has a metal hood at each end which throws a shadow on the curved joints of the flat ceilings, which results in the slight reduction observed in the lighting in line with the window seats. If there were no metal ends on the lighting fittings there would be no such shadow and consequently no reduction in the lighting. The transversal lighting fittings have the further advantage of being less exposed to damage when the luggage is being handled.

Observations made in service to date as regards the lighting installations of the forty new coaches, show that the discharge lighting up fittings give a perfectly workable use of the tubes and that contrary to general opinion, have a good effect upon their useful life.

The lighting installations of the post office vans.

The lighting installations used to date in the post office vans of the Deutsche Bundespost : opal glass globes in the letter sorting compartment and flat diffusers with opal glass with a protective metal grid in the parcels sorting compartments gave a lighting of 42.5 lux at table level; the installation of plexiglas diffusers open underneath made it possible to increase the lighting to 75 lux. In the last two years, trials of lighting by fluorescent tubes have been carried out on 16 coaches and in view of the results obtained, all the post office vans will be uniformly equipped with such lighting in the future. Although the new eight wheeled vans are 4 m longer than the old ones, the lighting at table level has been nearly doubled without it being necessary to increase the consumption of electricity. The question of the frequency has not been completely solved; it is probable that 100 Hz will be adopted.

Driving the dynamo from the axle by means of a belt has been given up in favour of a cardan shaft drive which has given good results on the whole. The drive takes place at the end of the axle so that the dynamos which are interchangeable can be fitted on the bogie frame where they can easily be got at.

In 1952, the Deutsche Post in its turn began to equip its mail post office vans

with fluorescent tubes, using the standard train lighting arrangement : generator driven by the axle, carbon cell field regulator and battery. The 24 V direct current produced was converted to 16.4 V alternating current by a commutator turning at 3 600 revs per min and was then raised to 220 V by means of a transformer of a power of 1 kVA. The fluorescent tube which is of the ordinary commercial type consumes with 220 V, 450 mA, whilst lighting up and 290 mA while it is alight. The current used by the converter is 10 A at 24 V. The ratio of transformation of the voltage increase is 16.4/220. The circuit adopted enables up to 7 tubes to be used. With this number of lamps, the current consumption is 26.6 A, to which must be added 10 A for the current consumption when the transformer is running light. The classic lighting with incandescent lamps uses these 37 A. The lighting of the post office vans requires 16 of 18 fluorescent tubes. If the consumption of the converter running light is included, i.e. 10 A, the actual current consumption amounts to 33.8 A. The more powerful lighting obtained therefore does not take any more power from the battery than the old incandescent lighting.

Thanks to the combination of inductance coils and condensers, perfect lighting by means of resonances and the oscillating up of the fluorescent tubes is obtained circuits set up. The lighting is assured from 125 V for all lengths of tube. To save the battery during the often prolonged standing of the post office vans when they are being loaded or unloaded, provision has been made to plug in the lighting installation to the local supply.

Lighting of the double decker and C4 üp coaches.

These rakes were put into service in 1954, and the C4 üp coaches of the main lines are fitted with fluorescent lighting of a new type of the VEB Mechanik Gaselan which consists of the following components :

1) 24/30 V 70 A generator, 335-470-2 200 revs per min driven by a flat belt;

2) device to tighten the belt with an average preliminary tension of 145 kg;

3) current limiter, intended to limit the current on starting to prevent the belt slipping;

4) regulating equipment with WKA carbon pile assuring the regulation of the voltage;

5) 250 Ah alcaline battery for the C4 üp coaches and 325 Ah for the double decker coaches;

6) rotary converter, 19 to 30 V D.C., 180 to 280 V A.C., 50 to 100 Hz;

7) regulator of the speed of rotation with feeler circuit depending upon the frequency, to regulate the rotary converter.

The double decker coaches are fitted with uncovered lamps, the C4 üp coaches with covered lamps forming a continuous luminous band along the longitudinal centre line of the coach.

During stops the current is supplied by the battery. When the running speed is about 19 km (12 miles)/h, the generator is automatically connected to the lighting installation. The regulator stabilises automatically the voltage of the charging current. When the running speed falls and the voltage of the generator falls below that of the battery, the generator is automatically cut out and the battery supplies the installation again. When there is no longer any danger of the driving belt slipping, i.e. at about 34 km (21 miles)/h, the current reaches its maximum intensity, i.e. about 85 A.

The fluorescent lamps receive their current through the rotary converter, which converts the direct current supplied by the generator or the battery into alternating current. To get a constant lighting, a frequency regulator is fitted which, no matter what the voltage, automatic-

ally adopts, thanks to a new fitting, the frequency of the existing A.C. commutator. As a result the fluorescent lamps always work under constant amperage, no matter what the direct voltage at the rotary converter. The intensity of the lighting is therefore always the same. As the A.C. voltage varies between 180 and 220 V, according to operating conditions, the frequency varies correspondingly from 50 to 100 Hz. At 180 V and 50 Hz the amperage is the same as at 280 V and 100 Hz.

When the installation is supplied from the standard supply system, a voltage of 180 to 190 V is required. So that the current through the lamps shall not be excessive, the normal A.C. voltage has to be reduced to 180/190 V by a transformer.

Whereas each C4 üp coach has its own lighting installation, the double decker rakes of four coaches are fitted with three installations consisting of a generator, a battery, a converter and the regulating components, which come into play should one of the generators or converters break down. The installations are mounted in the two end coaches and in one of the centre coaches. The other centre coach, which has no installation of its own, is supplied from the others.

The type VEB Gaselan fluorescent tube lighting has given absolutely satisfactory results during the year it has been in service. Lighting up always takes place perfectly, the tubes hardly ever go on and off, and the lighting in the compartments is bright and uniform. No difficulties have been experienced as regards maintaining these installations.

The lighting installations for the long distance coaches.

On the trains used for parties going abroad, the old lighting by incandescent lamps has been retained. This was to spare the other countries having trouble should anything go wrong with the fluorescent tube lighting, since this is not yet completely perfected, so that it was considered preferable to put up with increased consumption of electricity.

Résumé.

The above report shows that since the trains were first lit, from the days of the candle to the modern lighting by fluorescent tubes, with the various stages of oil, acetylene, oil gas and incandescent electric lamps, an enormous amount of work has been carried out to study and perfect it. The problem of an economical, rational lighting, meeting all requirements, is still far from being solved. We are only at the beginning of the technique of fluorescent lighting. Numerous problems still have to be solved in the case of fixed lighting installations : how much more numerous in the case of train lighting, which has to deal with so much more difficult conditions. The different systems are put forward with their advantages and drawbacks. Science and technique must continue to work unceasingly to find improvements and the time will come when the spirit of research in its turn will have solved this problem.

[656 .212 (73)]

Up-to-the-minute car reporting ...as the Erie does it.

Mechanized car reporting system, using IBM-Teletype equipment at Hammond, Marion and Meadville, provides advance yard offices and Cleveland headquarters with timely information concerning car movements.

(*Railway Age*, November 28, 1955).

Within 50 minutes after an eastbound freight train leaves the Erie's yard at Hammond, Ind. (just east of Chicago), the train consist is transmitted to major yards on the route of the train as well as to traffic offices and the general offices in Cleveland. Shortly thereafter, the consist is transmitted to off-line traffic offices.

To accomplish these results, the Erie has installed IBM card-processing machines in yard offices at Hammond, Marion, Ohio, and Meadville, Pa., and in the office of the car accountant in Cleveland. Additional Teletype equipment was installed at these and other offices, and three new carrier circuits were added: Hammond-Marion, Marion-Youngstown and Youngstown-Meadville. Elsewhere, existing railroad-owned circuits and printing telegraph equipment are handling car reporting traffic. Additions to the system will include the installation of card-processing machines at yard offices in Buffalo, Hornell, N. Y., and Jersey City.

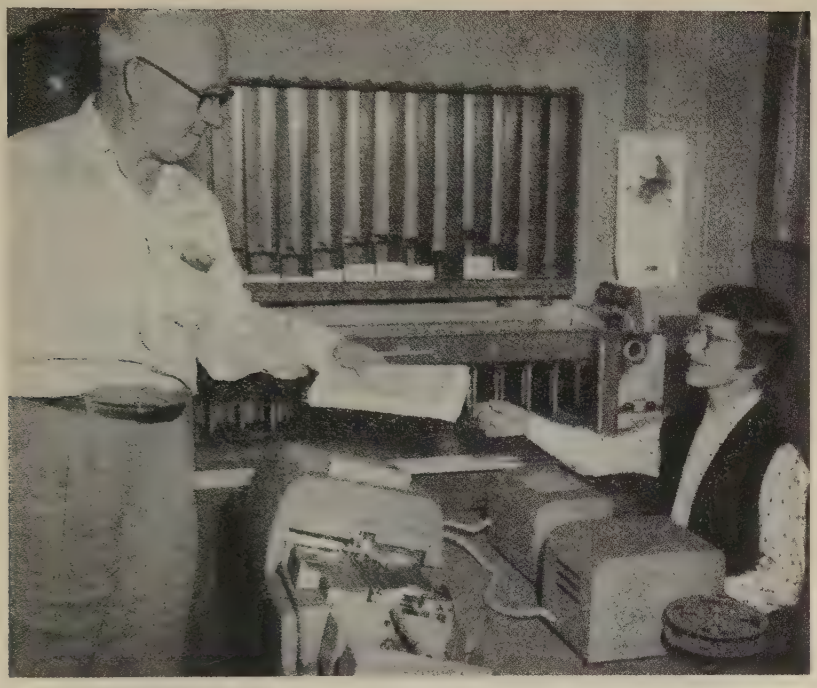
How the system operates.

Hammond is the originating assembly yard for eastbound trains, and the final break-up point for westbound trains on the Erie. Six types of IBM card processing machines were installed in the Hammond yard offices: (1) alphabetical key punch unit (makes punched cards); (2) interpreter unit; (3) card-to-tape unit; (4) tape-to-card unit; (5) sorting unit; and (6) tabulating unit.

When a train or a transfer cut arrives at Hammond from Chicago, the conductor brings his waybills to the yard office. The first step is to prepare a punched card containing all pertinent waybill information for each car. This is done by an operator, using the alphabetical key punch machines. Information punched on the card includes: car initial and number, whether loaded or empty, kind of car, net tons, gross tons, contents, destination, state, consignee, junction to and road, freight charges, origin station, shipper, waybill date and number, route, and special instructions. Sometimes this information is contained on two or three cards for the particular car.

Card interpreter.

The data on the cards at this stage is in the form of small rectangular holes. The cards are next passed through an interpreter machine which « reads » the holes, and prints the information on the cards. The interpreted cards are checked against the waybills, then inserted in the waybills and passed along to the yardmaster who will use them to classify cars and make up eastbound trains. The yardmaster arranges the waybills and cards in train order from head end to rear. Then the waybills and cards are separated, keeping each group in order.



Waybills go to operator who prepares punched cards from them containing pertinent information. Cards then go to...

Next the conductor's wheel report is prepared. A heading card is placed in the machine to print the train number, engine number, conductor's name, departing station, time of day and date. Then the punched cards, stacked in train order, are automatically fed into the accounting machine to print the required train information. The wheel report is automatically totaled to show the net and gross tons, as well as empty and loaded cars in the train. This wheel report is prepared in advance of train time, so that there is no delay in departure. The conductor picks up his wheel report and waybills, and is soon on his way.

Multiple sending of consists.

But the car reporting job has just begun. As soon as the wheel report is made, the cards are released and run through a card-to-tape machine which prepares a Teletype tape ready for transmission. Next the Hammond operator positions several hey switches on an electronic line multiplier, thus setting up circuit connections for the Teletype transmitter-distributor to Chicago, Huntington, Marion and Youngstown. He then feeds the consist tape into the transmitter-distributor, and presses its start button.

At the Chicago traffic office and Huntington (Ind.) telegraph office, the consist is received on a page printer.

At Marion, the consists is relayed through the depot telegraph office to the yard office where it is received on a page printer and reperforator.

Relay reporting.

The Youngstown operator in turn takes the tape from the reperforator and feeds

it into a transmitter-distributor, keys his electronic line multiplier for Cleveland, Akron, Meadville, Buffalo and Jersey City, and begins transmission. The transmitter-distributor is adjacent to the reperforator so he can begin relaying after a couple of feet of tape have issued from the reperforator. The incoming consist makes a tape and page copies at Cleveland, Meadville, Buffalo and Jersey City. At Akron veland. Within 50 min of the starting time at Hammond, all offices mentioned in the preceding discussion have received the complete consist.

Tape-to-card at next yard.

At Marion yard office, the incoming consist tape is run through a tape-to-card machine to produce cards for each

Card-to-tape machine which prepares a Teletype tape of the consist in train order. Cards are next sent to...

the consist is received on a page printer.

At Jersey City, an operator takes the incoming tape, feeds it into a transmitter-distributor, keys an electronic line multiplier, and transmits the consists to the New York traffic office at 50 Church street and to the Duane Street office (Piers 20 and 21). These offices obtain the consist on a receiving page printer.

Thus, within 10 min after Hammond starts sending a train consists, that consist is being received on a reperforator and/or page printer at yards and major offices on-line including the general office in Cle-

car on the eastbound train. One of the page copies is sent to the yardmaster so he can plan his work prior to the train's arrival. Upon arrival, the conductor turns in his waybills, and the cards prepared previously at Marion are put with them. New cards are made for cars picked up en route, and notations made on cards for cars set out en route. Then the cards and waybills are given to the yardmaster, whose procedure is a repeat of that at Hammond.

For westbound trains, this entire sequence of operations is reversed, with

the process starting at Meadville, the farthest point east at which the card-processing-machine part of the car reporting system has been installed.

Cleveland receives the consist in the form of page printer copies and a tape. This tape is run through a tape-to-card machine to produce punched cards, one card for each car. The cards and page copies are used for records, car tracing and accounting. The punched cards are used to prepare Erie's « Q. A. » (Quick Action) passing reports which are sent to off-line and on-line traffic offices and freight agents daily.

A feature of the Erie's method of car reporting is that the information from the waybill is manually punched on a card at one time, and one time only. All pertinent data is included in the first punching so the additional reports required can be obtained by machine processes with no further reference to the original waybill. The transportation office in Cleveland gets everything, and from this detailed information other reports can be prepared. Hammond yard office prepares the junction passing report for the traffic and revenue departments as well as the jumbo car record book for use at Hammond, and the interchange report in lieu of typing.

The various offices which receive copies of the consist being transmitted from Hammond use this information for notifying shippers and consignees of car movements, and for various traffic and operating studies and reports. At Youngstown the western district general manager receives a copy of every train consist, as does the eastern district general manager at Jersey City. Approximately 125 train consists are handled daily by the car reporting system.

Printing tabulator which prepares conductor's wheel report.

Advantages of new system.

The advantages of the car reporting system, in which the operation of business machines and a system-wide railroad-owned printing telegraph network are coordinated, are many. These benefits are evident in yards and terminals as well as to the superintendent of trans-

portation, car accountant, auditor of revenues, traffic department men, shippers and consignees. E. E. Seise, assistant to the president (Erie's man behind the system), summarized the advantages as follows :

« Printed conductor's wheel report instead of hand prepared report;

» Printed train consists and automatic card preparation for « Q. A. » (Quick Action) Car Locator Service report for shippers and receivers;

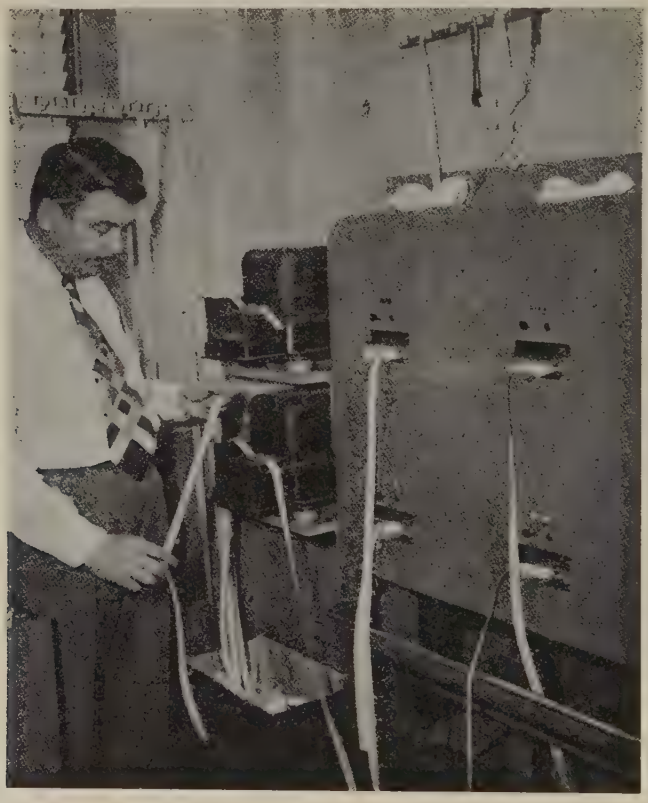
» Machine-printed interchange reports replacing manual work;

» Machine-printed outbound train consist, providing an immediate check of classification and yard handling;

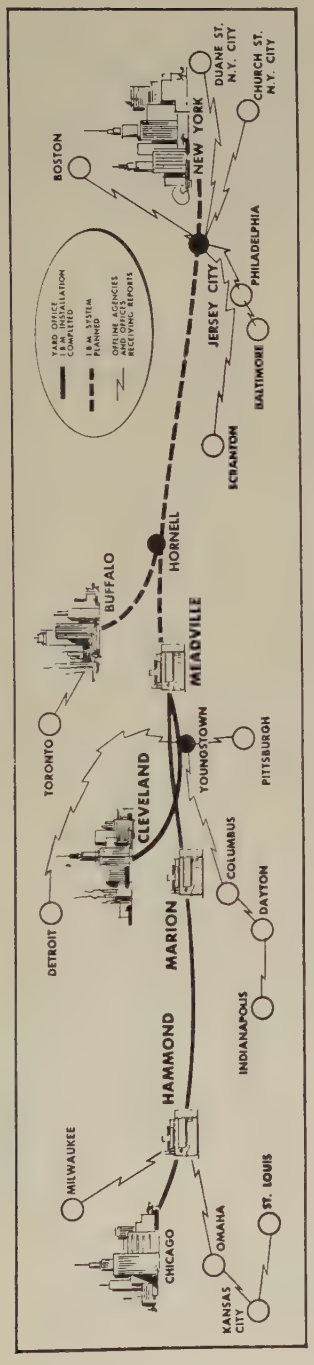
» An indexed yard car record printed automatically each day from punched cards showing daily records, and monthly to give permanent record. It shows arrivals of cars and forwardings and eliminates postings;

» An easily prepared passing report, still from the original punched cards, for revenue settlement with other carriers and for traffic department use;

» Advance notice from other yards in



Consist tape is sent on transmitter-distributor (left) and incoming train consists received on console reperforator (right).



Car reporting system will be extended to include all major yards.

form of inbound train consist transmitted from dispatching yard;

» One punching of waybill information produces cards which are used again and again. Transcribing of information from waybills is practically eliminated after the first punched cards are prepared;

» Reduction of errors in car initial and numbers, instructions, etc., which formerly resulted from numerous transcribing operations in manual set-up;

» No loss of speed or delay to train schedules at heavy car-card-punching points (receiving yards from connections) once operators are trained and new system organized to a normal routine;

» Very little dislocation of personnel. Regular yard personnel can readily be trained to take over the mechanical operation.

» When the communication equipment and business machines are coordinated, the adaptations are really tremendous », said Mr. Seise. « We are looking forward to the day when it might be possible to key punch a card from a waybill in a railroad yard on the west coast, and have that same card reproduced over and over again in each railroad yard, from the West coast to the East coast, without ever having to manually transcribe the data from the waybill. We believe the universal use of business machines in yard offices is a forward step in standardization of car reporting for all railroads, keeping shippers and receivers quickly informed about their car movements, and hence making possible more efficient operation through greater mechanization. »

Carrier circuits added.

For the past several years, the communications department has been improving circuits and installing carrier to provide system-wide printing telegraph service, the network now comprising about 4 150 circuits miles of carrier and 6 350 miles of

physical circuits. Also the Erie leases Teletype circuits to off-line agents as well as TWX service to other off-line offices.

The studies for the use of improved machine methods and the development of procedures for the yard and general offices are headed by E. E. Seise, assistant to the president; F. H. Menagh, superintendent of communications; and G. F. Dunathan, car accountant. The card processing machines are leased from the International Business Machines Corporation. The printing telegraph equipment was furnished by the Teletype Corporation, and was installed by the Erie communications department, as was the carrier equipment.

[621 .333]

Detecting flaws in traction gears (*).

If you know how to look and know what you are looking at, many gear failures can be avoided without unnecessary scrapping.

(*Railway Locomotives and Cars*, December 1955.)

Magnetic particle testing, because of its simplicity, sometimes deceives inspectors and causes them to reject gearing for any indication of surface irregularities. This may result in unnecessary scrapping of many gears and pinions through failure to recognize irrelevant indications and allow for variations in inspection techniques.

For instance, the sensitivity of the test will depend upon whether alternating or direct current is used. Because alternating current tends to flow principally along the surface of the conductor, the resulting magnetic field is limited to the metal near the surface of the part being examined. Direct current, on the other hand, penetrates more deeply into the material and therefore will show subsurface irregularities. Since surface flaws on gear teeth are of the greatest concern, the magnetic fields produced by alternating current will be suitable, provided sufficient strength of field (ampere turns) is used. In general, the magnetic field should approach saturation. This state is reached when the leakage flux causes a build-up of magnetic particles at sharp corners, or points where the section changes. A commonly used check of the magnetic field strength is to note whether a paper clip is attracted to the magnetized surface.

Residual magnetization not satisfactory.

In many cases, the residual method of magnetization is used rather than the continuous method. As a general rule, the residual magnetism method should be avoided because of the difficulty in obtaining a field intensity strong enough to give a clear indication of defects.

An important factor in determining the sensitivity of the test is the type of inspection medium used. For instance, a weak field will attract coarse elongated particles. These will produce visible indications, but they require tedious examination to be certain that the flaws are noted. These same weak fields would probably produce no indications with very fine particles in a wet inspection medium.

Another factor affecting sensitivity of the inspection is the direction of the field with respect to the flaw. Flaws parallel to the field will give the poorest indication, and flaws at right angles to the field will give the best. Fortunately, surface flaws in traction gearing are usually unidirectional, so two inspections with fields at right angles to each other are not necessary. Since the flaws are in an axial or nearly axial direction, the field should be at right angles to this, or in a circumferential direction.

(*) This is an abstract of a paper by J. B. Mac-Pherson and A. H. Prucknicki, both of General Electric Company, presented at the Fall General Meeting of the American Institute of Electrical Engineers, held in Chicago, October 3-7, 1955.

Once an indication has been observed and classified, the decision to be made as to acceptance or rejection of gear with the flaw. Only gears of sufficient quality to render satisfactory service for the desired life of the unit should be accepted. Standards of acceptance and rejection must, therefore, be based on a thorough understanding of what can, and cannot, be tolerated in service.

The decision as to acceptability of a part should not necessarily be based on the presence or absence of such things as forging folds, cracks, inclusions, or other abnormal conditions. Rather, it should be based on how the conditions found will affect the usefulness of the part. All imperfections are not necessarily defects requiring rejection of the part. If this fact is not properly recognized, inspection may be over-critical and satisfactory parts may be rejected. Since the major factor in judging the acceptability of a part is its performance in service, the value of any non-destructive test should be measured by the performance of the parts which have been inspected by this means and approved. The purpose of any periodic inspection in a maintenance program is to assure that the part is as good as necessary for this particular function and service. Inspection results should be considered and judged from this point of view.

The flaws usually observed may be grouped in three classes: material, manufacturing and service flaws.

Material flaws.

Since the bulk of railroad gearing is made from forged or rolled blanks, the material flaws encountered will be in the form of inclusions, or forging laps or folds. Inspectors are generally familiar with the characteristic indication of an inclusion, therefore, it will not be described; but a typical inclusion is shown in figure 1. Forging laps, on the other hand, are not so well known. This type of flaw occurs in fillets or at locations where section change, such as at rims or hubs. Usually, it penetrates straight in from the surface. A forging lap in the fillet between the web and hub of a gear is shown in figure 2. Forging laps do not occur in pinions. In this case, the blanks are hammer forged or manufactured from bar stock, hence it is impossible for the metal to have been folded or lapped on itself.

The presence of forging laps is not

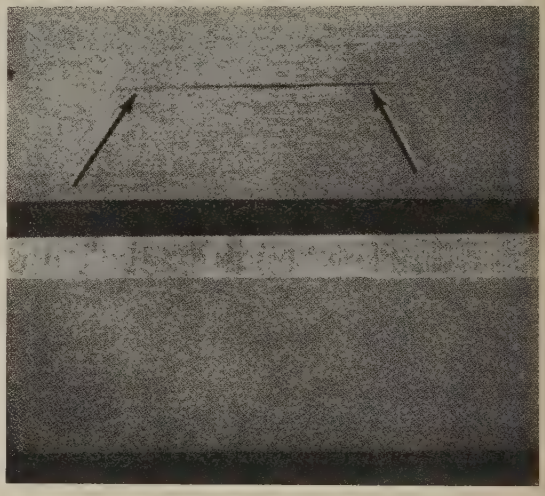


Fig. 1. — Gear teeth, showing typical inclusions

necessarily a cause for rejection of the part. Hubs and rim fillets are regions of relatively low stress and, therefore, forging folds or laps in these areas either will not increase in size or, if they do, the progress will be very slow. When forging defects are found, they may be ground out, provided their depth does not exceed 1/4 in. The bottom of the grind should be rounded to avoid unnecessary stress raisers. This figure of 1/4 in. is a rule of thumb, and hence only approximate. For instance, if the web is particularly thick and the bottom radius of the grind is generous, the 1/4-in. depth may be exceeded. These

ground areas should be checked annually to insure that cracks do not propagate in them.

Subsurface inclusions, particularly in tooth root areas, are important to the gear manufacturer as indications of the quality of the material. The more serious inclusions are those on the surface. If these are long and numerous, they may serve as starting points for fatigue failures. However, cases of fatigue failures on traction gearing starting from inclusions have been rare.

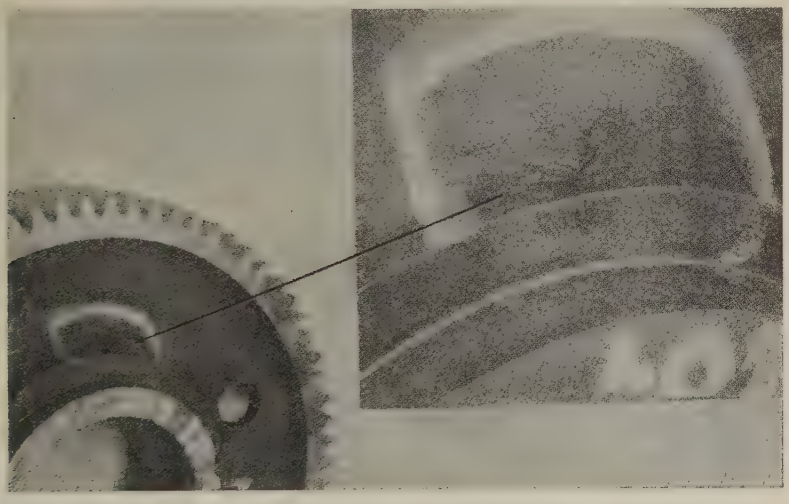


Fig. 2. — Gear with forging lap in hub fillet.

Manufacturing flaws.

Several types of indications might appear on gear teeth as a result of operations performed during manufacture. Quench cracks, machine tear marks, and grinding cracks are the most common causes of this type of indication.

Quench cracks result from unequal cooling rates in adjacent sections during the quench cycle of heat treatment. These cracks generally form at the ends of the teeth in the root area. Figure 3 shows typical quench cracks. Fortunately, such cracks are easily detected because they are usually long and deep and give strong indications. In most cases, the manufacturer's inspection detects quench cracks, so they are rarely found on gears in service. When quench cracks are found in a service inspection, they are cause for rejection of the gear or pinion.

Quench cracks, such as shown in figure 3, indicate a heat treatment problem. Sometimes it is difficult to distinguish them from fatigue cracks, and they should be judged as if they were fatigue cracks. The greatest danger from the presence of quench cracks is that part of the tooth may break at the crack and lodge in the mesh. Since quench cracks are fairly deep, tooth breakage from this cause will occur in the early stages of operation, by rupturing rather than by long-term fatigue. There have been cases where, although one or two teeth on a gear have broken off at the corners because of quench cracks, the gears have operated satisfactorily for a considerable time before the breakage was observed. In such cases, the broken pieces did not lodge in the mesh, but dropped to the bottom of the gear case.

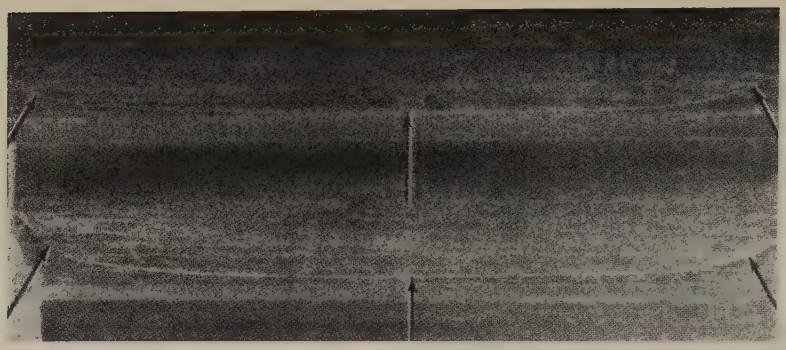


Fig. 3. — Pinion with quench cracks in teeth.

If the break in a gear tooth is from a corner, and is less than 25 % of the face width and the teeth adjacent to the broken tooth show no defects, the gear can be returned to limited service. A suggested way to limit the duty on such a gear is to confine its operation to lighter, less critical service. A pinion with a broken tooth, however, should be replaced. This is based on the fact that pinions make more revolutions than gears and therefore wear faster. Also, they cost less and are easier to replace than gears. A gear with more than two broken teeth should be examined closely to be certain there are no other fatigue cracks. It should also be checked for the amount of wear life remaining before deciding to retain it in service.

Machine tear marks are found only in the roots of teeth on protuberance-hobbed gearing. They never occur in gearing with fully ground teeth. These marks are believed to be caused by chips interfering with the flutes of the hob. A pinion with typical tear marks is shown in figure 4. They are very shallow in depth and in length. Their distribution is very random, and they always occur in an axial direction. Tear marks are not a cause for scrapping the gear or pinion.

Grinding cracks result from an excessive rate of grinding. This may be caused by either too fast a grinding wheel speed or too fast a feed of the wheel. Grinding cracks are very fine and generally run perpendicular to the axis of the gear or pinion. In some cases, they form a chicken wire pattern, as shown in figure 5. Another common appearance is the fish-tail pattern shown in figure 6.

All manufacturers try to avoid producing grinding cracks when grinding teeth. Gears in service found to have grinding cracks should be viewed with suspicion. The manufacturer should be consulted if such cracks are found at the first

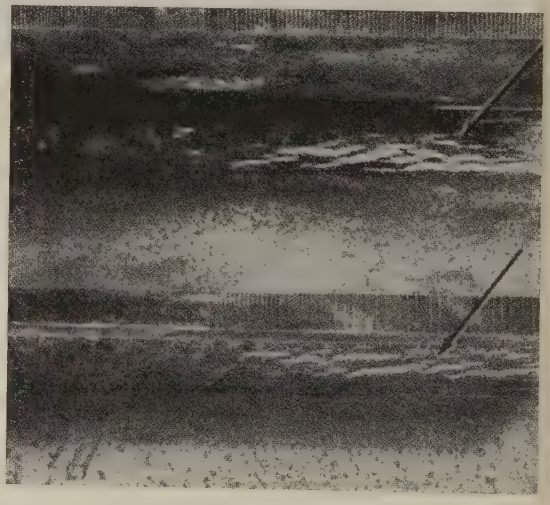


Fig. 4. — Pinion, showing tear marks at the roots of the teeth.

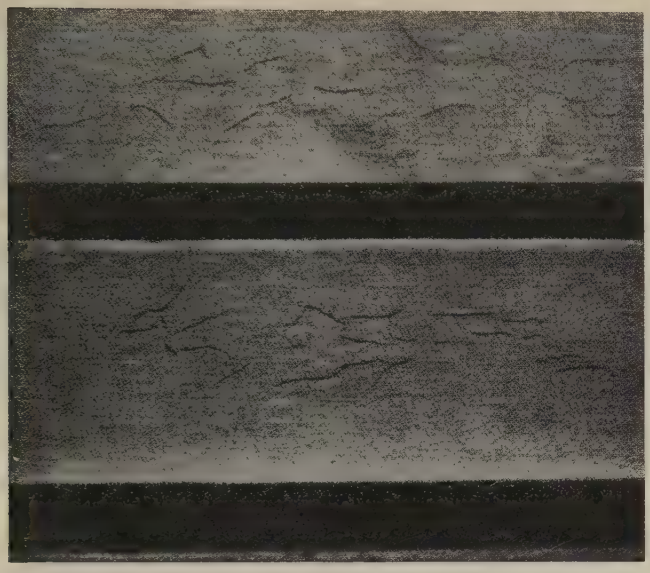


Fig. 5. — Grinding cracks forming a chicken wire pattern.

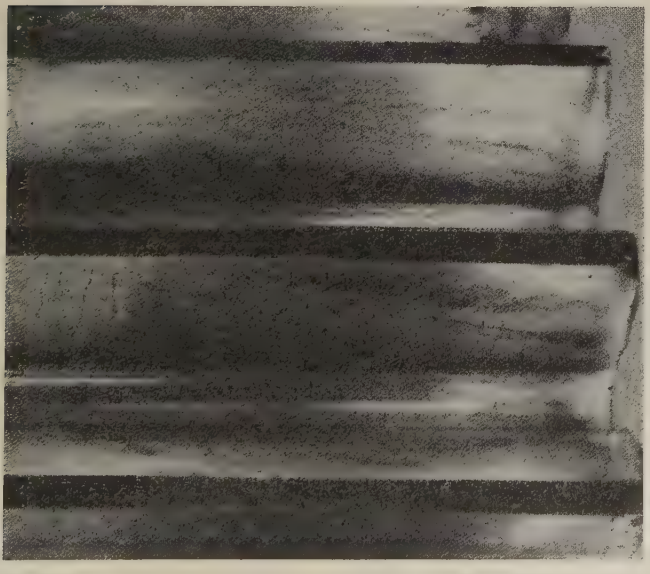


Fig. 6. — Grinding cracks forming a fish-tail pattern.

inspection. Grinding cracks may or may not be harmful. If they are shallow and the tooth loading is conservative — particularly if the gear material is shallow-hardening steel — grinding cracks will not develop into fatigue cracks, but will gradually disappear as wear occurs. If residual tensile stresses occur at the surface as a result of improper heat treating — especially with deep-hardening steels — the residual stresses from the grinding process and the tensile stress from tooth loading can add up to the point where fatigue failure will start. In such cases, grinding cracks are a cause for rejection of the part.

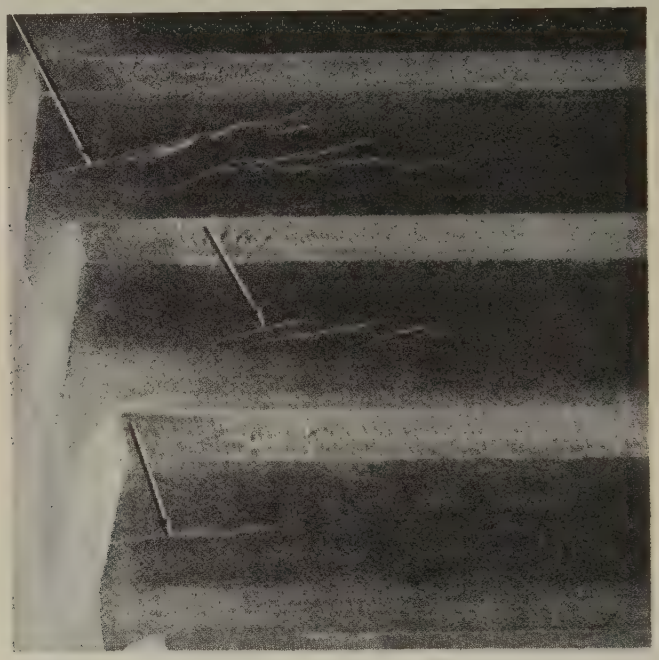


Fig. 7. — Typical fatigue cracks in gear teeth.

Service flaws.

The third group of indications are those resulting from service flaws. These flaws, resulting from operation of the gearing, are called fatigue cracks. In most cases, they start at the root fillet on the side near the motor and progress upyard toward the tip of the tooth in a sweeping curve. Figure 7 shows a typical fatigue crack. Some fatigue cracks occur in the roots of the teeth and run axially along the root as shown in figure 8. Such fatigue cracks are easily mistaken for machine tear marks if the root is unground. Grinding the indication with a small hand grinder and retesting will determine whether the flaw is a fatigue crack or not. If the indication does not reappear, it was a machine tear mark and not a fatigue crack. An infrequent type of fatigue failure is that in which the crack at the root of the tooth progresses radially in the rim toward the bore, as shown in figure 9.

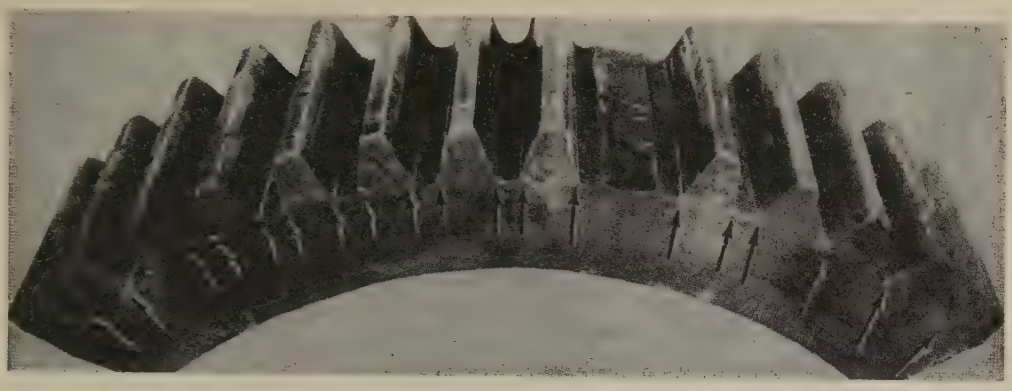


Fig. 8. — Axial fatigue cracks at roots of gear teeth.

Fig. 9. — Radial fatigue cracks in gear rim.

While inclusions and grinding cracks are the origins of many fatigue failures. end loading of the teeth is probably the greatest single cause. End loading may be the result of shaft deflection, bearing clearances and wear, or misalignment of the motor frame. It is easily detected by examining the teeth to determine the location of the contact area.

Another cause of fatigue failures is the presence of high residual tensile stresses in the root areas. It is impossible to

detect residual stresses except by tedious and expensive destructive testing techniques which are outside the scope of this paper.

The final cause of fatigue failures is surface decarburization. This results in surface areas with low carbon content and, consequently, extremely low fatigue strength and wear life. If decarburization occurs in the root areas on heavily loaded gearing, fatigue failure or broken teeth will result. If it is located on the wear areas of the teeth profiles — particularly if the area is large and deep — the gearing will wear at an excessive rate.

Traction gearing is an exact piece of machinery — carefully designed and accurately manufactured. Hence, it should be properly cared for. Growing appreciation of this fact has brought about a rise in the standards of gear inspection and maintenance on numerous railroads. Intelligent use of non-destructive testing techniques and correct interpretation of the indications obtained, play an important role in this work.

The foregoing discussion has been presented for the purpose of assisting the operator to detect and properly evaluate surface flaws in traction gearing. The data cited lead to the following conclusions :

1. Certain inspection techniques are best adapted to indicate flaws of the surface type.

2. Gearing giving indication of flaws need not necessarily be scrapped. In some instances the flaws may be corrected. In other cases, the character of the flaw and the type of service may permit the part to be continued in use.

3. As skill and experience are gained in the techniques of inspection and the interpretation of the results, road failures resulting from gear trouble will be reduced and the reliability level of motive power raised.

[621 .431 .72 (42)]

British Railways locomotive orders.

Contracts placed for more than 200 000 b.h.p. covering 171 locomotives at a cost of more than £ 10 000 000.

(*Diesel Railway Traction*, January, 1956.)

The English Electric 3 300-b.h.p. Diesel-electric locomotive of Co-Co type powered by two Deltic engines bringing a passenger train from the north into Preston Station.

After many months of consideration and negotiation, orders were placed, and announced, in November, for a total of 171 line-service Diesel locomotives for operation on the English Regions of British Railways, though with probable operation to Edinburgh and Glasgow in the Scottish Region.

In announcing these orders, which cover 13 different types, the British Transport Commission emphasised that this was a pilot scheme under which trials would be made before any further orders were placed under the projected £ 1 200 000 15-year scheme for the modernisation of British Railways, which envisaged the possible construction of up to 2 500 line-service Diesel locomotives additional to hundreds of Diesel railcars and numerous shunting locomotives.

Three power classes.

Three general categories are included in the pilot scheme, viz. : (A) 800-1 000 b.h.p. locomotives for freight service; (B) 1 000-1 250 b.h.p. locomotives for general-purpose duties; and (C) 2 000-

Main-line Diesel locomotive orders, British Railways, 1955.

Order No.	No. of locos.	B.H.P.	Trans-mission type	No. of engin.	Wheel arrange-ment	Main contractor	Engine make	Trans-mission maker	Mechanical portion make	Region
1	10	2 300	Electric	1	1-Co-Co-1	Sulzer	Sulzer (1) 12LDA28	Crompton-Parkinson	British Railways	London Midland
2	10	2 000	»	1	1-Co-Co-1	English Electric	English Electric-16SVT	English Electric	English Electric	Eastern
3	5	2 000	Hydraulic	2	C-C	North British	M.A.N.	Voith	North British	Western
4	20	1 160	Electric	1	Bo-Bo	B.T.H.	Sulzer 6LDA28	B.T.H.	British Railways	London Midland
5	10	1 100	»	1	Bo-Bo	English Electric	Napier Deltic (2)	English Electric	English Electric	Eastern
6	20	1 160	»	1	Bo-Bo	Birmingham C. & W.	Sulzer-6LDA28	Crompton-Parkinson	Birmingham C. & W.	»
7	20	1 250	»	1	A1A-A1A	Brush-Bagnall	Mirrlees-JVS12	Brush	Bagnall	»
8	20	1 200	»	1	Co-Bo	Metro-Vick	Crossley (3)	Metro-Vick	Metro-Vick	London-Midland
9	10	1 000	»	1	Bo-Bo	North British	M.A.N.	General Electric	North British	Eastern
10	6	1 000	Hydraulic	1	B-B	North British	M.A.N.	Voith	North British	Western
11	20	1 000	Electric	1	Bo-Bo	English Electric	English Electric 8SVT	English Electric	English Electric	London Midland
12	10	800	»	1	Bo-Bo	B.T.H.	Paxman	B.T.H.	Clayton	»
13	10	800	»	1	Bo-Bo	North British	Paxman	General Electric	North British	Eastern

(1) Twin-bank (2) Triple-bank 18-piston (3) Two-stroke

2 300 b.h.p. units for the heaviest main-line passenger and freight operation. All of these are single-unit locomotives. The whole pilot scheme may be divided another way into 141 locomotives ordered complete from British private locomotive builders and 30 for which the mechanical portions are to be built in the works of British Railways. In the latter case it is not clear whether the designs of the complete locomotives of two classes — are to be the responsibility of the railway, or of industry, as in the published statements Sulzer is shown as the main contractor for the 2 300 b.h.p. locomotives — the most powerful of the whole series — and B. T. H. as main contractor for 20 locomotives of 1 160 b.h.p.

Allocation to regions.

Particulars of the division of work over the 13 different types of locomotives are given in the Table on the preceding page. But the analysis may be carried further. Western Region is being allocated 11 locomotives, five of 2 000 b.h.p. and six of 1 000 b.h.p.; and all of these are of Diesel-hydraulic type. The London Midland Region is to acquire 50 locomotives from industry plus 30 built in its own shops with engine-transmission equipment bought outside. Eastern Region, and presumably this includes North Eastern Region, is to be given 80 locomotives also. The Scottish Region is not being allocated any locomotives of its own; nor is the Southern Region, though in the case of this latter Region something like 15 equipments of 400 b.h.p. have already been ordered from English Electric for installation in multiple-unit trains.

On a power basis, London Midland Region is to have 10 locomotives of 2 300 b.h.p., 20 of 1 200 b.h.p., 20 of 1 160 b.h.p., 20 of 1 000 b.h.p., and 10 of 800 b.h.p. Eastern Region is to have 10 locomotives of 2 000 b.h.p., 20 at 1 250 b.h.p., 20 at 1 160 b.h.p., 10 at 1 100 b.h.p., 10 at 1 000 b.h.p., and 10 at 800 b.h.p. All these are Diesel-electric. The Western Region is taking the five 2 000 b.h.p. and six 1 000 b.h.p. Diesel-hydraulic locomotives.

Wheel arrangements of the Diesel-electric locomotives are all 1-Co-Co-1, Co-Co or Bo-Bo, except the asymmetrical Metro-Vick locomotives of 1 200 b.h.p., which are to have the Co-Bo layout, and the 20 Brush-Bagnall locomotives of 1 250 b.h.p. which will have the A1A-A1A wheel arrangement. The Diesel-hydraulic notations are C-C and B-B; and in regard to weight it appears that weights of 130 tons or more may be countenanced in the 2 000-2 300 b.h.p. Diesel-electric locomotives.

Engine types.

In regard to engine makes and types, Sulzer leads the field with 50 engines, of which 10 are to be of the notable 12-cylinder twin-bank type of 2 300 b.h.p., and 40 are to be of the 1 160 b.h.p. six-cylinder vertical model with the same cylinder measurements as in the twin-bank engine. English Electric is to furnish 30 engines — 10 of 2 000 b.h.p. from 16 cylinders arranged *en V*, and 20 of 1 000 b.h.p. from eight vertical cylinders; and Napier — an E. E. group partner — is to build 10 of the Deltic engines, three-bank pressure-charged machines of 18 pistons operating on the two-stroke opposed-piston principle, and giving an output of 1 100 b.h.p. There are to be 20 engines of the Mirrlees four-stroke, 1 250 b.h.p. type similar to those now operating in Ceylon; and 20 of the Crossley eight-cylinder V two-stroke type as used in Western Australia and Eire. Paxman, with railway oil engines operating in between 15 and 20 different countries, is to supply 20 engines of 800 b.h.p. Finally, M. A. N.-type engines, for which the North British Locomotive Co. holds a licence, are to be supplied to the extent of 26 of 1 000 b.h.p.

The 20 Brush-Bagnall locomotives, the

most powerful in regard to b.h.p. of the locomotives in the medium-power category, are to have the Mirrlees JVS12 engine set to give 1 250 b.h.p. at 850 r.p.m. coupled to an 828 kW main generator; the locomotives have an estimated weight of 104 tons, an overall length of 57 ft., and are to be geared for a top speed of 75 m.p.h. Ten of the B. T. H. locomotives are to have Paxman's most modern form of four-valve V engine, the pressure-charged 16 YHXL, having a continuous output of 800 b.h.p. from 7 in. by 7 3/4 in. cylinders running at 1 250 r.p.m., and the same engine is to be used in 10 of the N. B. L. locomotives in conjunction with electric transmission.

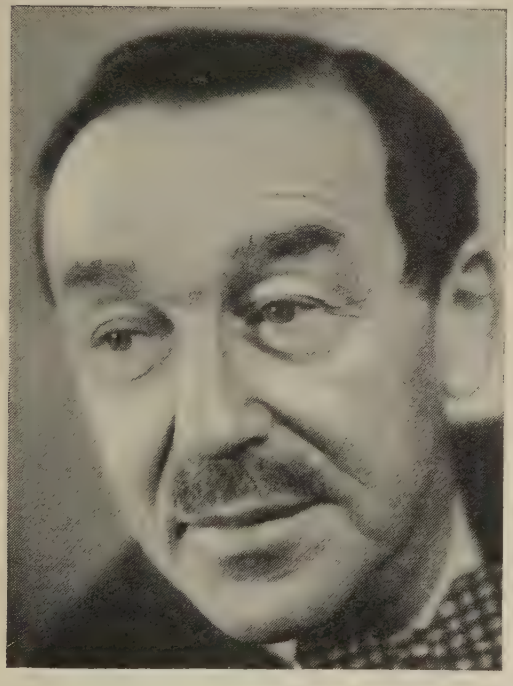
Nominally six private builders are to participate in the construction of mechanical portions, some as main contractors and some as sub-contractors; but it is to be remembered that English Electric, which is charged as main contractor with the responsibility of 40 mechanical portions, has available to it for production not only its own shops at Preston, but also the establishments of the companies in the English Electric Group, namely the Vulcan Foundry and Robt. Stephenson & Hawthorns.

[385 (09 .2]

OBITUARY.

Fritz STEINER,

Engineer, former Manager of the Transport Office of the Swiss Federal Post Office and Railway Department.
Former Member of the Permanent Commission of the International Railway Congress Association.



We learnt with great regret of the death, on the 3rd October 1955, of Mr. Fritz STEINER, former Manager of the Transport Office of the Federal Post Office and Railway Department and former member of the Permanent Commission of our Association.

A native of French Switzerland, Fritz STEINER was born at Neuchatel, on the 3rd December 1885. In 1905, he entered the Federal Polytechnical School which awarded him an electrical engineering diploma in 1909. His theoretical studies and then his practical activities in the construction of dynamos as assistant to Professor Wyssling and Fahrny, the two great pioneers in the electrification of the railways, coincided with the epoch in which Switzerland began seriously to consider the progress made in electric traction on the railways. Because of his natural aptitude Mr. STEINER was closely associated with this movement. The years 1910-1912 found him in the Railway Department of the firm of Brown Boveri & Co., at Baden. In 1912, in the spring, he entered the Research Department of the Oerlikon Engineering Works, and in the spring of 1914 the Railway Department of the same Company. On the 1st March 1918, he joined the Swiss Federal Railways and thus began the most important chapter of his life.

At that time, under the management of Chief Engineer Huber-Stockar, the first important stage in the electrification of the railways was put in hand. The designing of the traction stock and the relations with the manufacturing firms formed part of the work of the Traction Department and Shops of the General Management of the Federal Railways, which exerted the deciding influence

thereon. Mr. STEINER was first of all traction engineer attached to this Department, then he became responsible for its management as Chief Engineer. In the whole world, there could be no other example of a task of such magnitude carried out by such a simple organisation and in such a short time, and Mr. STEINER was responsible for a great deal thereof. Above all, he was responsible for the very heavy and difficult job of designing the electric locomotives for the Federal Railways and for supervising their construction at the highest level. The fact that the Federal Railways have to-day a sufficient number of electric traction units, which are technically perfect, is largely due to Mr. STEINER. To the precise qualities of a competent engineer, he joined the distinguished characteristics of his native province, full of delicacy and humour, with the courteous and friendly manners of the gifted intellectual who is an adept in the art of life. These qualities enabled him to bring to a satisfactory end the most difficult discussions and to solve the most thorny problems in the most satisfactory way, so that all those who worked with him were inspired to enthousiastic collaboration.

The profound experience and clarity of judgement, which he brought to the difficult problems of electrifying the railways, earned him a reputation far beyond the frontiers of his own country. Thus for three years the Federal Railways made him responsible not only for advising the Skoda Company at Prague on the introduction of electric rolling stock, but also the Swedish State Railways for the electrification of the Goteborg-Boras line and the Belgian Railways for the electrification of the Brussels-Antwerp line. An imposing list of publications shows his copious experience in the field of electric traction on the railways.

In 1942, Mr. STEINER entered the Transport Office of the Federal Post Office and Railway Department as head of the technical department. The financial recovery and technical overhaul of many private railway undertakings, essential for the economy of Switzerland, had to be taken in hand and Mr. STEINER had the difficult task of dealing with the financial and technical problems of this act of assistance. Thanks to his knowledge and tact, he was able to bring to a successful conclusion within a very short period this new task of confederal solidarity, which was of such great importance for Swiss economy. In 1946, he became Assistant Manager of the Transport Office and then Manager in 1950, and it was as head of this important division of the Post Office and Railway Department that he was called upon on several occasions to play a decisive part regarding the fundamental elements of the Swiss communication system.

On the 31st August 1951, Mr. STEINER left the Transport Office to enjoy a well earned retirement.

The Swiss Government made him responsible for representing the Confederation on those railway undertakings which were of particular interest to the authorities on account of their importance. In addition to these functions, the Swiss manufacturers of electric rolling stock and various private railway companies asked for his collaboration in solving many problems in the field of their activities.

All those who worked with him or on his instructions will remember with gratitude his kindness and the pains he took to sponsor the interest of the staff under his orders.

Mr. STEINER was appointed a member

of the Permanent Commission of our Association at the Lucerne Congress in 1947, in which he took an active part as delegate of the Federal Transport Office and member of the Executive Organising Committee of the Session. He took part in the Rome Congress in 1950 as representative of the Swiss Federal Post Office and Railway Department, as well as at the Enlarged Meeting of the Permanent Commission at Stockholm in 1952.

In spite of his absorbing duties Mr. Steiner was always a faithful and devoted collaborator of our Association. Because of the affability of his character and his gifted personality, he was able to gain the estime and sympathy of all his colleagues.

We offer his family our sincerest sympathy.

The Executive Committee.

NEW BOOKS AND PUBLICATIONS.

[**385** (09 .2 (494)]

MATHYS (E.), former Librarian to the Swiss Federal Railways, with the collaboration of H. MATHYS. — **Männer der Schiene** *(Men of the Railway)*. — One volume (5 $^{1}/_{2}$ × 8 $^{1}/_{4}$ inches) of 310 pages, copiously illustrated. — 1955, Bern, Kümmerly & Frey, Geographischer Verlag, Hallerstrasse 6/8. (Price : 11.50 Swiss francs.)

The first volume published under this title appeared in 1947, the year in which the centenary of the first Swiss railway line was celebrated.

In this country, where the people have always been keenly interested in railway questions, the work was warmly welcomed by the railwaymen as well as the general public.

So many personalities were connected with the creation of the railway system, that the author had regretfully to make a selection of some of them only.

These two circumstances led him to publish a second edition which is in fact a new book.

In this, homage is paid to a new group of men who must be included amongst the creators of the railway : organisers and directors, engineers of recent times, builders of lines through the Alps, engineers of the mountain lines, and electrical engineers.

In writing their biographies, the author has tried to define the part each one played and to stress the reasons why the people of Switzerland should be grateful to them. In reading these recitals we are made aware once more of the obstacles and difficulties which had to be overcome to reach the valleys and tunnel through or climb the mountains.

The work is to some extent a new history of the Swiss Railways from the first beginnings down to the present day. We assist at the establishment of many lines whose amalgamation ended by forming the present system with all the improvements which have made it a first class instrument.

Each note, devoted separately to one of the heroes of the book — there are some sixty of them — is illustrated by a photograph so that posterity will have a portrait of these eminent men. The illustrations also include engravings of remarkable structures, events of special importance, and commemorative monuments.

In order to write such an authenticated record, the author has had recourse to a great many sources of recognised value. He lists the chief of these at the end of the book.

E. M.

[**385** (09 .3 (45)]

Ferrovie Nord Milano 1879-1954 *(North of Milan Railways 1879-1954)*. — One brochure (7 $^{7}/_{8}$ × 10 $^{5}/_{8}$ inches) of 64 pages, copiously illustrated. — 1954, Published by the *Ferrovie Nord Milano* Company.

It was in 1875 that at the suggestion of the Belgian, Albert Vaucamps, and on the basis of a project studied by the engineers Ambrogio Campilio and Emilios Bianchi that the convention for the construction of the railway line from Milan to Saronno was approved. The line was opened to traffic on the 22nd March 1879.

This note by the Management of the North of Milan Railway is intended to commemorate this event.

By successive additions the system has now increased to 247 km (153 miles), 80 km (50 miles) of which are double track.

The work is a monograph as well as an historical review in which the improvements made during these 75 years are recalled.

Comparative statistics give the figures for the years 1880, 1900, 1938 and 1953 for the rolling stock, the staff, the services and the traffic.

The possibilities of the railway compared with the road are analysed under the following headings : transport capacity, average speeds, punctuality, safety, convenience, and cost of transport.

Amongst the most remarkable innovations mention is made of the automatic block, the complete electrification of the system, the renewal of the rolling stock. The district lying to the north of Milan has enjoyed the fortunate influence of numerous and rapid communications.

Showing a deficit from 1945 to 1949, the railway is once again paying its way thanks to the modernisation measures introduced and to the better user of the stock and staff.

In the illustrations, the authors have included the most noteworthy specimens of ancient and modern locomotives and the new passenger coaches. Two bridges and some stations are also depicted. The views of beautiful scenery recall the lake district which the railway has rendered easy of reach.

If this book is a faithful record of the path travelled, it also leaves us with a well founded confidence in the future.

E. M.

IXth PAN AMERICAN RAILWAY CONGRESS

According to an information received from the Permanent Commission of the Pan American Railway Congress Association, the IXth Pan American Railway Congress, which had to take place in April 1956, has been postponed. The date fixed for the Opening Session of this IXth PAN AMERICAN RAILWAY CONGRESS is the 30th August 1957.

This Session will therefore be held during the year of the Centenary of the Argentine Railroads.

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